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# Cytological studies on the genus hybrids among *Triticum*, *Secale* and *Aegilops*, and the species hybrids in *Aegilops*

By Fuyuwo KAGAWA and Yoshiwo CHIZAKI

With 90 figures

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## Material and methods

In the present paper the cytological studies on  $F_1$  plants raised according to the following combinations of parents are reported. Their chromosome numbers certified by us are shown in the parentheses.

*Triticum compactum* HOST U.A.C.<sup>(1)</sup> no. 1 ( $n = 21$ ) × *Secale cereale* L. U.A.C.  
no. 1 ( $n = 7$ )

*T. Spelta* L. Ordinaire blanc sans barbes ( $n = 21$ ) × *S. cereale* L. U.A.C. no.  
1 ( $n = 7$ )

---

(1) U.A.C. = Utsunomiya Agricultural College.

*T. durum* Desf. Blé dur de Médéah ( $n = 14$ )  $\times$  *S. cereale* L. U.A.C. no. 1 ( $n = 7$ )

*Aegilops triuncialis* L. ( $n = 14$ )  $\times$  *S. cereale* L. U.A.C. no. 1 ( $n = 7$ )

*Ae. cylindrica* HOST ( $n = 14$ )  $\times$  *S. cereale* L. U.A.C. no. 1 ( $n = 7$ )

*Ae. ovata* L. ( $n = 14$ )  $\times$  *S. cereale* L. U.A.C. no. 1 ( $n = 7$ )

*Aegilops cylindrica* HOST ( $n = 14$ )  $\times$  *Aegilops speltoides* TAUSCH. var. *ligustica* BOISS. ( $n = 7$ )

*Ae. cylindrica* HOST ( $n = 14$ )  $\times$  *Ae. ovata* L. ( $n = 14$ )

*Ae. cylindrica* HOST ( $n = 14$ )  $\times$  *Ae. ventricosa* TAUSCH. ( $n = 14$ )

All  $F_1$  plants were in main intermediate between the two parents regarding the characters in spikes, leaves, growth habits, time of heading and others. They were all completely sterile by open pollination.

The anthers were fixed in CARNOY's solution, preserved in 70% alcohol and later the PMC's were observed in BELLING's acetocarmine. For  $F_1$ -s *T. compactum*  $\times$  *S. cereale* and *T. durum*  $\times$  *S. cereale*, paraffin materials were also used. They were cut 16–17  $\mu$  thick and stained with HEIDENHAIN's iron-alum-haematoxylin.

## Results of observation

### I. Intergeneric hybrids between *Triticum* and *Secale*

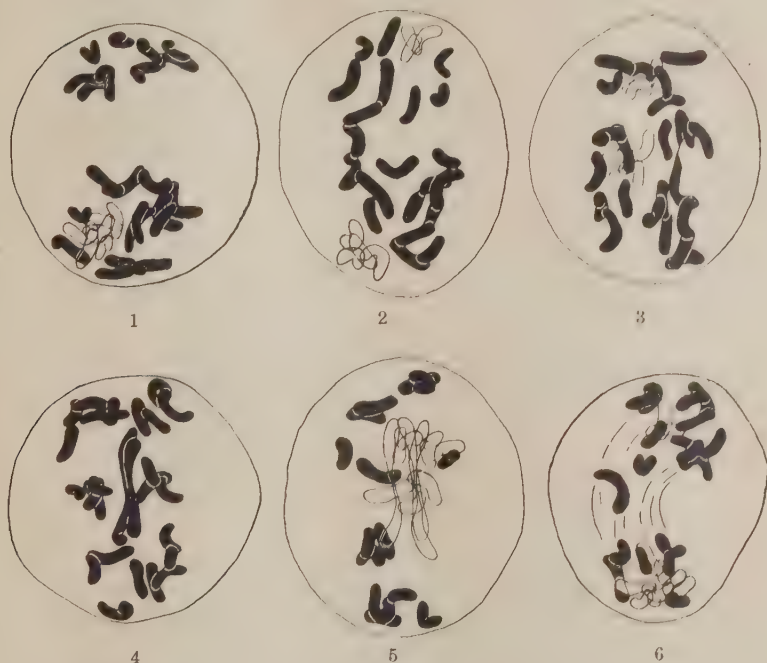
#### 1. *Triticum compactum* $\times$ *Secale cereale*

Cytological studies of  $F_1$  formed between hexaploid species of *Triticum* and rye were hitherto undertaken by a number of investigators. But the *Triticum* species used by them as parents was *vulgare* or *Spelta*, and the cytological studies of  $F_1$  between *T. compactum* and *S. cereale* were not yet made.

In our laboratory, 8  $F_1$  plants were raised by crossing *T. compactum* ( $n = 21$ ) with the pollen of *S. cereale* ( $n = 7$ ), and in  $F_1$  meiosis 28 univalent chromosomes were observed in most cases. They were usually arranged near the poles after diakinesis (Fig. 1), and afterwards moved toward the equatorial region (Fig. 2). Such behaviour of chromosomes was reported by KIHARA (1931, 1932) to be the norm shown by univalents in meiosis of inter-specific and inter-generic  $F_1$ -s of *Triticum*, *Aegilops* and *Secale*.

This was most clearly observed in  $F_1$  *T. compactum*  $\times$  *S. cereale*, while in other  $F_1$ -s reported in the present paper the behaviours of chromosomes were observed to be more or less modified.

In first metaphase often 1-3 bivalent chromosomes composed of 2 elements of similar size connected end to end appeared together with univalents (Figs. 3, 4, 5). The diploid number of chromosomes was counted as 28, the sum of the haploid ones of the parents.



Figs. 1-6.  $F_1$  *T. compactum*  $\times$  *S. cereale*. First division. Side views.  $\times 1150$ ; 1-2,  $28_I$ ; 3,  $1_{II}+26_I$ ; 4,  $2_{II}+24_I$ ; 5,  $3_{II}+22_I$ ; 6, curved spindle,  $28_I$ .

The frequency of observing bivalents in a PMC was as follows:

Number of bivalents.....	0	1	2	3
Frequency .....	125	70	21	5
	n = 221			

In Fig. 6 the spindle is quite long and curved.

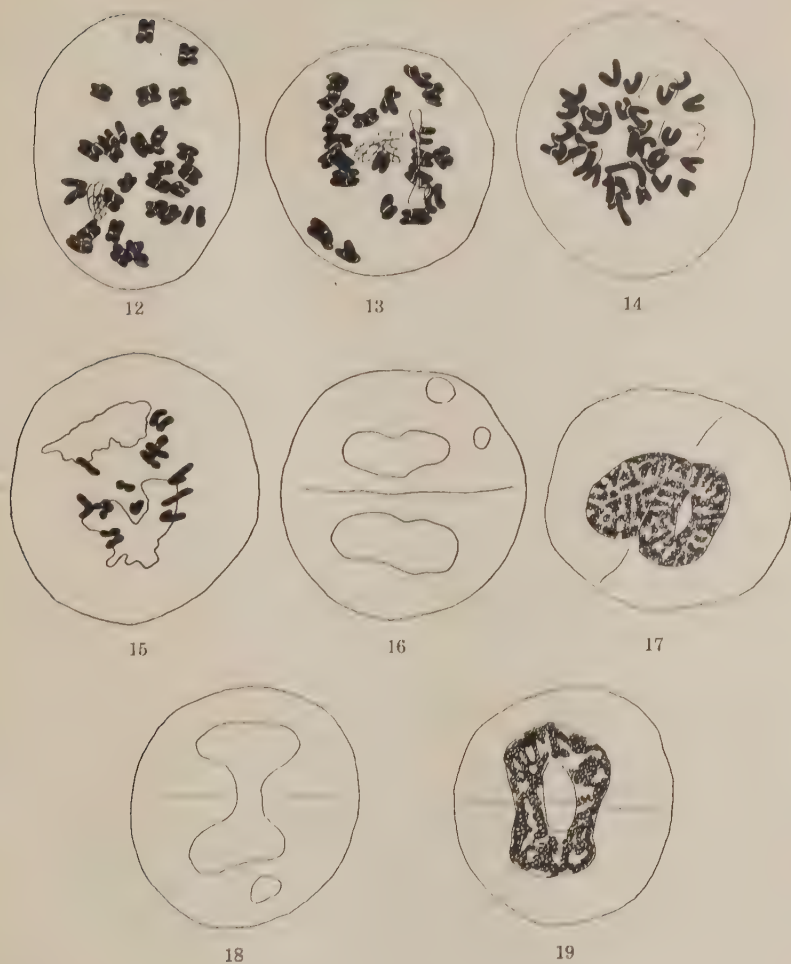
In a number of PMC-s, most of the 28 univalent chromosomes were arranged on the equatorial plane in metaphase, while a few were located more or less nearer the poles (Fig. 7), though occasionally, all chromosomes located themselves on the equatorial plane as univalents (Fig. 8). The unfrequency of the occurrence of chro-



Figs. 7-11. *F<sub>1</sub> T. compactum*  $\times$  *S. cereale*. First division. 9, 11, polar views; others side views.  $\times 1150$ . 7-10, all or almost all chromosomes are located at equatorial region; in 9 a chromosome located apart from it is shown in white; 7-8, chromosomes not yet split; 9, chromosomes show longitudinal split; 10, only the chromosomes clearly observable are drawn: a few other ones are located within the group; chromosomes longitudinally split; 11, all chromosomes are located on the equatorial plane in a form of ring, leaving the central part unoccupied.

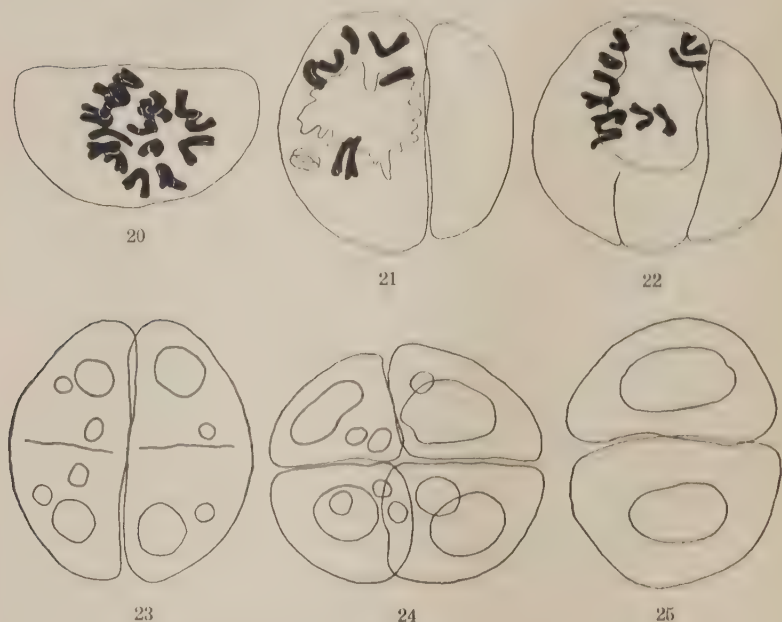
mosome conjugation is favourable for bringing about the arrangement of chromosomes of such kinds. The longitudinal split appeared then in these chromosomes (Figs. 9, 10).

In Fig. 11 the univalents showing the longitudinal split are observable on the periphery of the equatorial plane leaving its central part unoccupied.



Figs. 12-19. F<sub>1</sub> *T. compactum* × *S. cereale*. First division: 14, 17, oblique views; others side views. ×1150. 12, longitudinal split of all the univalents at earlier stage; 13, ditto, a bivalent is not yet disjoined; 14, separation of split halves of univalents located mostly at equatorial region; 15, late anaphase; 16, formation of extra nuclei; 17, telophasic nuclei of ring shape; 18, connection of two nuclei; 19, ditto, two nuclei are connected by two very thick bridges forming a ring in side view.

From the chromosome condition as shown in Figs. 8 and 11, the non-reduction and the subsequent formation of diploid pollen grains might be expected. The analogous possibility was observed by AASE (1930) in  $F_1$  *T. vulgare*  $\times$  *S. cereale*.



Figs. 20-25.  $F_1$  *T. compactum*  $\times$  *S. cereale*. 20-23, second division.  $\times 1150$ . 20, metaphase showing dyad and monad chromosomes; 21, metaphase in one of the two cells; all the chromosomes except one (in white) are located on the equatorial plane: the other cell contains no chromosome; 22, metaphasic group of chromosomes in one of the three cells formed by first division. In 21 and 22 some chromosomes are arranged rather closely, so that for them only the border line of the group is drawn: 23, late telophase showing numerous extra nuclei; 24, tetrad cells containing extra nuclei; 25, dyad cells.

Often, however, the splitting of univalents took place in earlier stages as shown in Fig. 12. In Fig. 13 26 univalents are seen to be split, while other 2 unsplit chromosomes remain yet conjugated end to end, forming a bivalent.

In first anaphase, the distribution of chromosomes was irregular; in Fig. 14, which shows the stage following those of Figs. 8 and



11, the split halves of univalents are more or less separated. In later anaphase they moved either towards different poles or passed to the one pole lying side by side (Fig. 15).

Some of the univalents showing longitudinal split, which were remaining near the poles since earlier stage, may enter the anaphasic groups of chromosomes without much changing their position. In late anaphase, some split halves of univalents or the entire univalents showing split were found lagging behind. At telophase extra nuclei were frequently formed from the laggards or owing to the irregular distribution of chromosomes (Fig. 16).

Occasionally, the telophasic nuclei were reconstructed in a form of rings (Fig. 17), which owes to the arrangement in rings of anaphasic chromosomes arriving at the poles.

The telophasic nuclei were very often connected together by a chromosome bridge, and in some cases two large bridges connected the two nuclei forming a large ring in side view (Figs. 18, 19). Occasionally three cells were formed by a tripolar spindle.

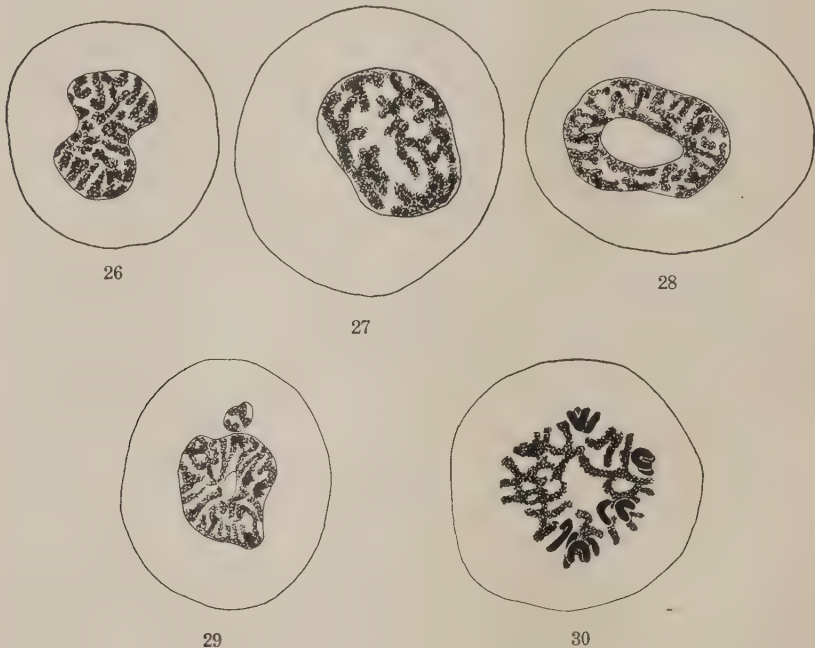
At second metaphase both the chromosomes of double and single structure were observed, corresponding to the chromosome behaviour in first division (Fig. 20). At anaphase the chromosomes of double structure were usually separated into their halves, though the chromosome distribution was quite irregular and lagging chromosomes were often observable.

Occasionally, all the chromosomes were contained in one of the two or three cells formed by the cleavage furrows in first division, and they have undergone there the second division (Figs. 21, 22). At late telophase extra nuclei were very often formed, which are derived from the laggards (Fig. 23). Usually 4, occasionally up to 7 microspores were formed from a PMC (Fig. 24), and often dyad cells were produced (Fig. 25).

The restitution nuclei of round or dumb-bell shape were not rarely formed (Figs. 26, 27), though in other cases such of ring shape were reconstructed (Fig. 28), and occasionally extra nuclei were observable outside of the ring (Fig. 29).

The restitution nuclei in ring form must have been formed in a PMC in which all the chromosomes were located on the periphery of the equatorial plane leaving its central part unoccupied as shown in Fig. 11. Fig. 30 shows a stage next to that of Fig. 11. In this figure the split halves of some univalents which are more or

less separated from their partners and lying on different optical planes are shown, and other chromosomes are already not clear in their outlines. Such chromosome arrangement may result in a nucleus in the shape of a ring as shown in Fig. 28, which is a polar view of the PMC, where the ring shaped nucleus is entirely of a different nature compared with that shown in Fig. 19.

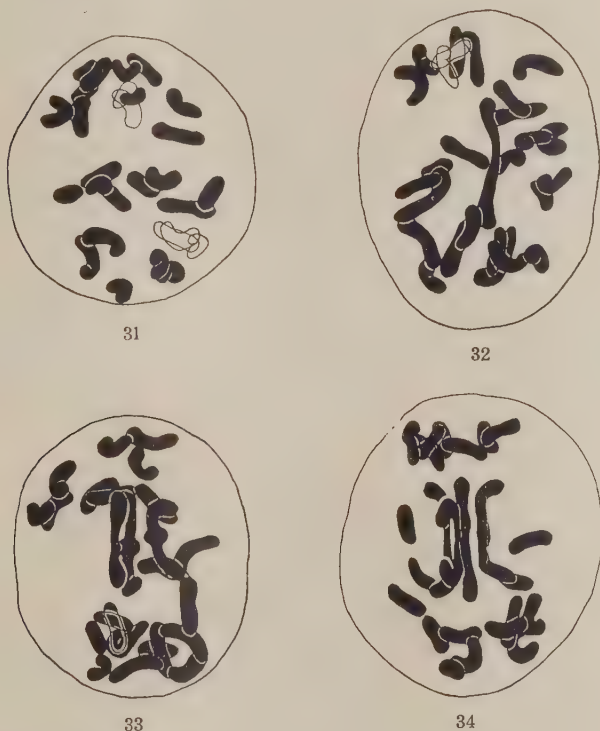


Figs. 26-30.  $F_1$  *T. compactum*  $\times$  *S. cereale*. Restitution nuclei.  $\times 1150$ . 26, dumb-bell shaped; 27, round; 28, ring-shaped, polar view; 29, ditto, with an extra nucleus; 30, formation of restitution nucleus in ring shape: 5 pairs of split halves of univalents are comparatively easily observable along their outline, while other chromosomes becoming to be alveolated; polar view.

The formation of restitution nuclei in  $F_1$  *T. compactum*  $\times$  *S. cereale* was quite frequent, so that the dyad pollen grains with diploid number of chromosomes may often be produced.

2. *Triticum Spelta* × *Secale cereale*

Cytological studies on  $F_1$  between *T. Spelta* and *S. cereale* were already undertaken by AASE (1930). The writers obtained one  $F_1$  plant by crossing *T. Spelta* ( $n=21$ ) with the pollen of *S. cereale* ( $n=7$ ), where the chromosome behaviours were in main similar to those reported by AASE.



Figs. 31-34.  $F_1$  *T. Spelta* × *S. cereale*. First division. Side views.  $\times 1300$ .  
31, 28 $_{I}$ ; 32, 1 $_{II}$ +26 $_{I}$ ; 33, 3 $_{II}$ +22 $_{I}$ ; 34, 4 $_{II}$ +20 $_{I}$ .

In heterotypic metaphase all or most chromosomes appeared as univalents (Fig. 31), but the bivalents conjugated end to end were not rarely observed (Figs. 32-34). The frequency of the number of bivalents in a PMC is as follows:

Number of bivalents..	0	1	2	3	4	
Frequency .....	57	36	22	17	4	n = 136

The range of the number of bivalents was 0-4, quite the same as reported by AASE (1930).

### 3. *Triticum durum* × *Secale cereale*

Cytological studies of  $F_1$  between *T. durum* and *S. cereale* were made by AASE (1930). We raised one  $F_1$  plant in the cross *T. durum* ( $n = 14$ ) × *S. cereale* ( $n = 7$ ).

At first metaphase in a large number of PMC-s, only the univalents were observed (Fig. 35), which were distributed irregularly in a PMC after diakinesis, though often 1-5 bivalents appeared together with univalents (Figs. 36-41).

The bivalents were usually composed of two chromosomes of similar size conjugated lengthwise. But, ring-shaped bivalents were occasionally observed (Fig. 37), of which more than one was never formed in a PMC. Bivalents of compact nature were not met with. The diploid number of chromosomes was 21 as will be expected.

The frequency of observing bivalents in a PMC was as follows:

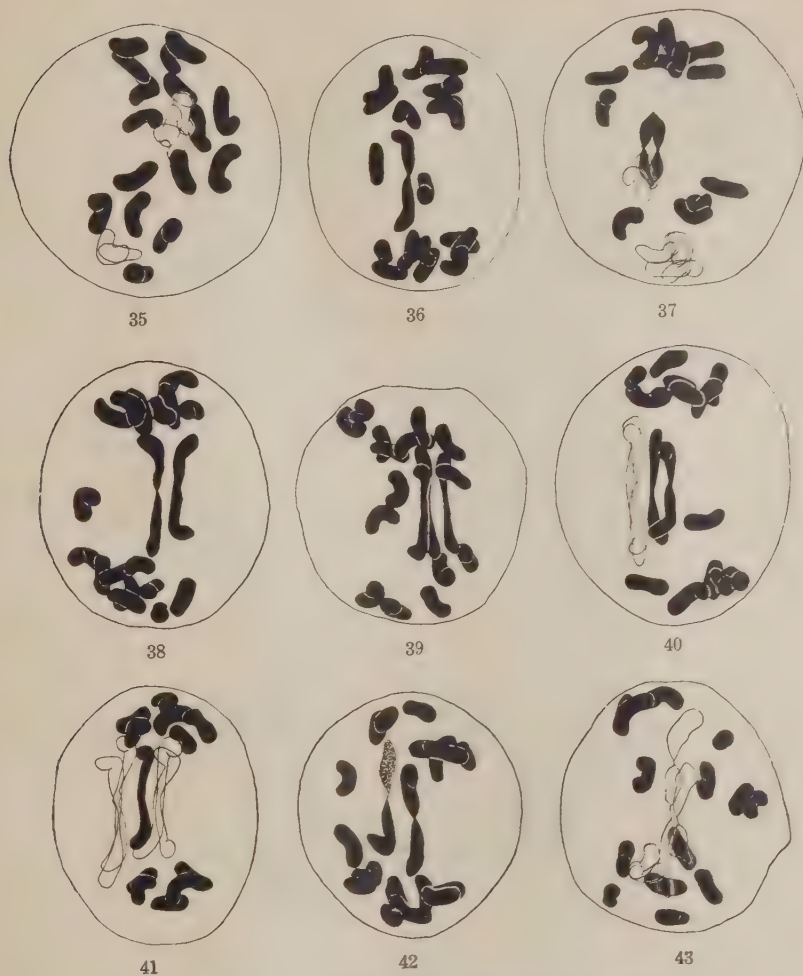
Number of bivalents.	0	1	2	3	4	5	
Frequency .....	150	97	59	17	3	1	n = 327

AASE (1930) observed up to 4 bivalents in  $F_1$  of the same combination of parents.

In very rare cases two or three chromosomes of different size conjugated end to end forming a bi- or tri-partite chromosome (Figs. 42, 43), and in some cases the spindle was quite long and sharply curved (Fig. 44).

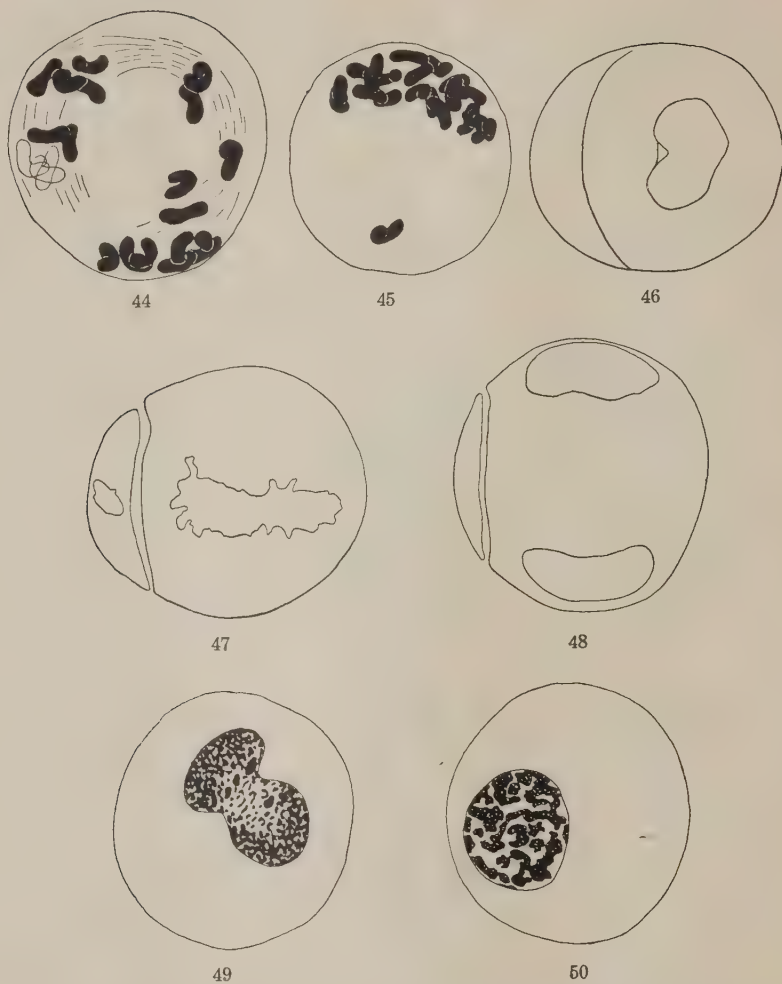
The bivalents disjoined as usual and their separated elements passed to different poles, and it seems that the univalents distributed at two poles after diakinesis may mostly remain at their position to be included in two nuclei formed by first division.

The numbers of chromosomes at two poles were usually not very much different from each other, but occasionally all or most chromosomes were observed at one of the two polar regions, thus for instance, in Fig. 45, 20 and 1 chromosomes are observable at each respectively.



Figs. 35-43.  $F_1$  *T. durum* × *S. cereale*. First division. Side views.  $\times 1300$ .  
 35,  $21_I$ ; 36,  $1_{II}+19_I$ ; 37, 1 ring shaped bivalent and  $19_I$ ; 38,  $2_{II}+17_I$ ; 39,  $3_{II}+15_I$ ; 40,  $4_{II}+13_I$ ; 41,  $5_{II}+11_I$ ; 42,  $1_{II}+1$  bipartite +  $17_I$ : dotted chromosome is quite smaller than its partner, thus forming a bipartite; 43,  $1_{II}+1$  tripartite +  $16_I$ : among 3 elements composing the tripartite the difference in size is evident; the middle one is the smallest, the upper one median and the lower one largest.





Figs. 44-50.  $F_1$  *T. durum*  $\times$  *S. cereale*.  $\times 1300$ . Side views. 44, 45, 46, first division. 44, extremely curved spindle; 45, 1 and 20 chromosomes are located at two polar regions; 46, a nucleus in one of the 2 cells formed by the cleavage furrow in first division: in the other cell no chromosome is contained; 47-48, second division; 47, metaphase, in one of the 2 cells most chromosomes are contained; 48, 2 telophasic nuclei, the stage which comes next to 46; 49-50, restitution nuclei.



In Fig. 46, a PMC is shown in which all the chromosomes are contained in a nucleus in one of the two cells formed by the cleavage furrow in first division. Fig. 47 shows a second metaphase following first division in which the chromosome distribution analogous to that shown in Fig. 45 occurred. Fig. 48 presents a stage which comes next to that in Fig. 46, where the equational division of all chromosomes may be possible, so that the formation of dyad pollen grains is not excluded.

The restitution nuclei of dumb-bell or round shape were occasionally observed (Figs. 49, 50).

## II. Intergeneric hybrids between *Aegilops* and *Secale*

### 1. *Aegilops triuncialis* × *Secale cereale*

Cytological studies on  $F_1$  hybrids between *Ae. triuncialis* and *S. cereale* were already undertaken by KARPECHENKO and SOROKINA (1929) and VON BERG (1931). In our laboratory also the cross *Ae. triuncialis* ( $n=14$ ) (Fig. 51) × *S. cereale* ( $n=7$ ) (Fig. 52) was made and 10  $F_1$  plants were raised.



51

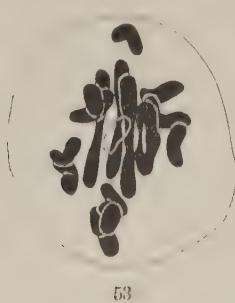


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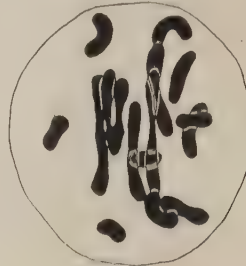
Fig. 51. *Ae. triuncialis*, gemini; Fig. 52. *S. cereale*, gemini. Side views.  $\times 1360$ .

At metaphase of first division, bivalents and trivalents composed of two or three chromosomes of similar size were observed together with univalents (Figs. 53–60). The bivalents were usually of loose type, but some were ring-shaped and occasionally compact gemini

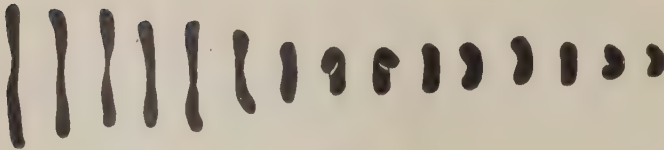
were also observed (Figs. 53, 55, 56, 60). The trivalents were usually V- or Y-shaped (Figs. 57, 59, 60), but sometimes they were



53



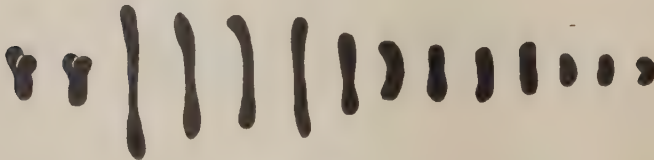
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55



56

Figs. 53-57.  $F_1$  *Ae. truncialis*  $\times$  *S. cereale*. Chromosomes in first metaphase. Side views.  $\times 1360$ . 53,  $4_{II} + 13_I$ ; 54,  $6_{II} + 9_I$ ; 55,  $7_{II} + 7_I$ , one ring shaped bivalent; 56,  $7_{II} + 7_I$ , two compact gemini; 57,  $1_{III} + 4_{II} + 10_I$ .

of more or less straight rod (Fig. 58). The diploid number of chromosomes was 21, as will be expected.

The frequency of observing tri- bi and univalents in a PMC is shown below:

No. of trivalents	3	2	2	2	1	1	1	1
„ „ bivalents	1	4	3	2	5	4	3	2
„ „ univalents	10	7	9	11	8	10	12	14
Frequency	1	5	10	2	19	42	1	2 n=82

Often, however, the trivalents were lacking, and only the bi- and univalents were observable (Figs. 53–56). In such cases the frequency of the number of bivalents was as follows:

No. of bivalents.....	3	4	5	6	7
Frequency .....	1	8	36	66	18 n=129

KARPECHENKO and SOROKINA (1929) observed, in early anaphase of the first meiosis of PMC-s of  $F_1$  ( $2n = 21$ ) of *Ae. triuncialis*  $\times$  *S. cereale*, usually 5, less frequently 6–7 bivalents conjugated end to end and 7–11 univalents. They state that in later anaphase of the same division up to 7 large chromosomes may be observed at the poles, which were esteemed by them to be presumably the separated partners of bivalents. But whether the latter were formed by allosyndesis or autosyndesis among *Aegilops* chromosomes was not decided by them.

VON BERG (1931) observed, in first meiosis of PMC-s in  $F_1$  ( $2n = 21$ ) of *Ae. triuncialis*  $\times$  *S. cereale*, up to 7, in most cases 5–6 bivalents, and other chromosomes were found to be univalents. According to him, the number of univalents was sometimes 7, which were all large, while in other cases certain numbers of small univalents were observed besides them thus increasing the total number of univalents. Here, the number of small univalents was dependent upon that of bivalents, and the diploid number as counted for both the univalents and bivalents in a PMC corresponded always to the sum of the haploid numbers of the parents, i.e. 21.

The author recognized that the chromosomes in  $F_1$  derived from *Ae. triuncialis* were small while those from *S. cereale* large, and also that the bivalents were formed by autosyndesis among 14 chromosomes of *Ae. triuncialis*, leaving 7 large *cereale* chromosomes, and

in some cases a certain number of *triuncialis* ones too, as univalents. But, the identification of 7 large *cereale* chromosomes from *triuncialis* ones seems not to have been made always in later stages for instance in second metaphase.

In order to know the size of univalents, we observed the first metaphase of PMC-s in which tri- and bivalents were contained together with a certain number of univalents. The latter in these PMC-s presented no or only a scarce amount of foreshortening, enabling us easily to know their exact size. The results can be seen below:

Composition of chromosomes	No. of univalents	No. of large chromosomes in univalents	No. of PMC-s
III+II+I	7-14	5-8	21
II+I	7-11	6-8	71

Thus the number of large chromosomes in univalents is not much apart from 7, though not always equal to it as was reported by VON BERG.

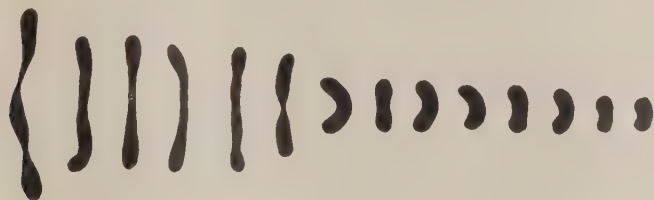
Comparing the size of gemini between *Ae. triuncialis* and *S. cereale* in side views of first meiosis (Figs. 51, 52), we found that the gemini of *S. cereale* are in general larger than those of *Ae. triuncialis*, though in each species there are some differences in size among the gemini. LEWITSKY (1931) also observed that there is a certain size difference among the somatic chromosomes of *S. cereale*, and the same was also reported by KORCZAGINA (1932) in *Ae. triuncialis*. However, we were not able to make clear what relation exists in chromosome size between the largest chromosome in *Ae. triuncialis* and the smallest one in *S. cereale*.

It must be remarked here that the estimation of the size of meiotic chromosomes is very difficult, owing to a foreshortening of some degree, and especially so in the case of bi- and trivalents of loose type as they are often stretched to opposite directions and do not present their normal size. The estimation of the size of compact gemini or of that of ring-shaped bivalents is also not easy owing to the same reason.

In the observation, where the foreshortening was taken into careful consideration, the composing elements of bi- and trivalents, which were not much stretched, appeared in some cases to be smaller than larger univalents, but in some other they were found larger than

the smaller univalents in a PMC, and there was no clear size difference between these elements and the larger univalents. Thus, we could not decide with certainty that the 7 large *cereale* chromosomes always become univalents.

The fact that the 14 chromosomes of *Ae. triuncialis* may form by autosyndesis 7 bivalents is not proved hitherto in the studies of meiosis in  $F_1$ -s between *Ae. triuncialis* and other *Aegilops* species and between *Ae. triuncialis* and *Triticum* species.



58



59



60

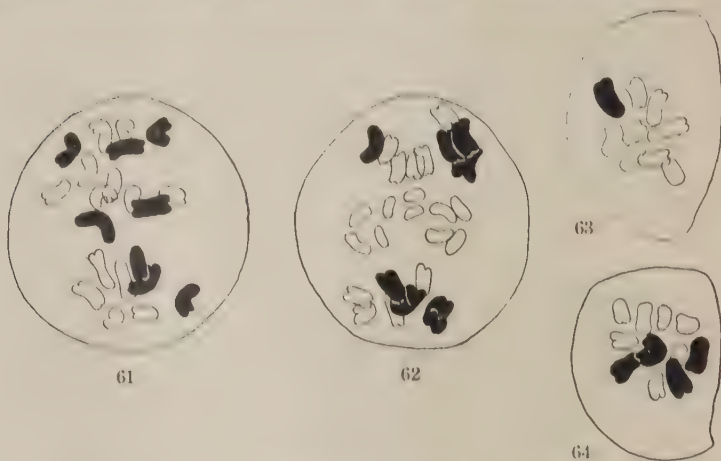
Figs. 58-60.  $F_1$  *Ae. triuncialis*  $\times$  *S. cereale*. Chromosomes in first metaphase. Side views.  $\times 1360$ . 58,  $1_{III} + 5_{II} + 8_I$ ; 59,  $2_{III} + 3_{II} + 9_I$ ; 60,  $3_{III} + 1_{II} + 10_I$ .

PERCIVAL (1930), KAGAWA (1931) and KIHARA and LILIENFELD (1932) observed up to 11-12 bivalents in meiosis of  $F_1$  *Ae. triuncialis*  $\times$  *Ae. cylindrica*. If the chromosomes of *Ae. triuncialis* form up to 7 bivalents, the chromosomes of *Ae. cylindrica* must form more than 4 bivalents, which was not proved in other studies, for instance, in those of KAGAWA (1928, 1929, b) and KIHARA and LILIENFELD (1932)



in meiosis of  $F_1$ s between *Ae. cylindrica* and *Triticum* species or other *Aegilops* species.

According to KIHARA and LILIENFELD (1932), *Ae. triuncialis* may be an allotetraploid species, though the two genomes contained in it may not be differentiated much from each other. It is possible to recognize in  $F_1$  *Ae. triuncialis*  $\times$  *S. cereale*, that the chromosome conjugation occurs frequently by autosyndesis among *triuncialis* chromosomes. It seems not unreasonable, however, to think that between some chromosomes of *Ae. triuncialis* and *S. cereale* allosyndetic con-



Figs. 61-64.  $F_1$  *Ae. triuncialis*  $\times$  *S. cereale*. Large chromosomes are shown in black.  $\times 1360$ . 61-62, first anaphase, side views; 61, chromosomes being split; 62, some pairs of split halves are seen at equatorial region and their partners are going to pass to different poles. 63-64, second metaphase, polar views; 63, all chromosomes probably dyads; 64, all possibly except one dyads.

jugation takes place. Further, for the formation of trivalents or tripartites, both the chromosomes of *triuncialis* and of *cereale* probably take part. The frequent conjugation of chromosomes of related genera was observed for instance by CHIZAKI (1932) in meiosis of  $F_1$  *Aegilops speltoides* ( $n = 7$ )  $\times$  *Triticum monococcum* ( $n = 7$ ), where up to 7 bivalents were formed.

As stated before, though the size verification of chromosomes is not easy, we could yet observe that in anaphase of first division 5-8



chromosomes out of 21 were larger than others. The exact number was, however, difficult to be decided, owing to the foreshortening of chromosomes (Figs. 61, 62).

The number of second metaphasic chromosomes was various, and we could observe that a certain number of them was considerably larger than others (Figs. 63, 64), all or most of which might have been derived from *S. cereale*. The more precise study is, however, necessary in order to draw the exact conclusions regarding the categories of chromosomes in  $F_1$  meiosis. In some cases dyad pollen grains were found.

## 2. *Aegilops cylindrica* × *Secale cereale*

By crossing *Ae. cylindrica* ( $n = 14$ ) (Fig. 65) with the pollen of *S. cereale* ( $n = 7$ ) one  $F_1$  plant was raised.

In side views of first metaphase, 2–7, usually 4–6 bivalents were observable together with univalents (Figs. 66, 67, 68), and often, one or more trivalents were also observed. Bivalents were in most cases

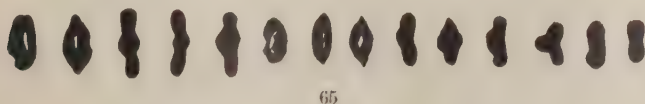
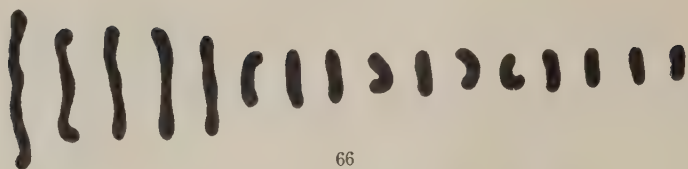


Fig. 65. *Ae. cylindrica*, gemini. Side view.  $\times 1360$ .

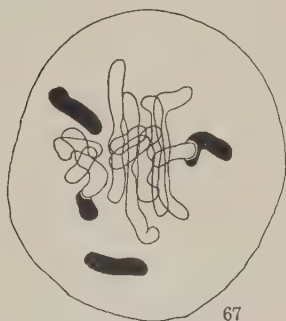
of loose type, but occasionally of ring form (Figs. 68, 69). Trivalents were seen to consist of three chromosomes connected lengthwise and presented V shape (Figs. 69, 70). The diploid number of chromosomes was 21, as will be expected.

At first metaphase all or most univalents were usually located at the equatorial region where the bivalents and trivalents situated themselves, and only a small number of univalents appeared at polar regions.

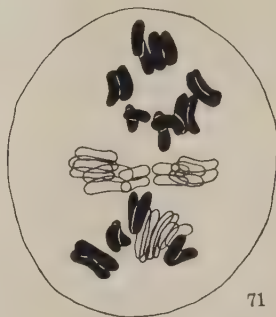
The gemini of *Ae. cylindrica* (Fig. 65) were found in general to be smaller than those of *S. cereale* (Fig. 52) in side views, though their size difference could not exactly be made out. On the contrary, *Ae. cylindrica* showed a certain difference in size among its gemini, as also seen by KAGAWA (1929, a) in root tip cells of the same species, where the ratio ca. 2:1 was detected between the longest chromo-



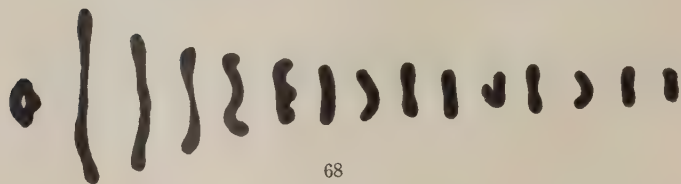
66



67



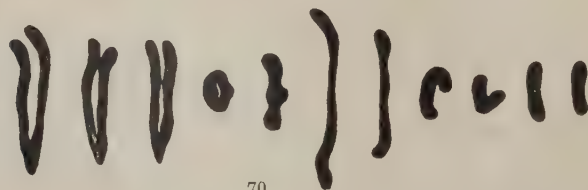
71



68



69



70

Figs. 66-71. *F<sub>1</sub> Ae. cylindrica* × *S. cereale*. Chromosomes in first metaphase except 71. Side views. ×1360. 66,  $5_{II}+11_I$ ; 67,  $6_{II}+9_I$ ; 68,  $6_{II}+9_I$ , one ring shaped bivalent; 69,  $1_{III}+4_{II}+10_I$ ; 70,  $3_{III}+4_{II}+4_I$ ; 71, first anaphase, chromosomes homotypically split, some at equatorial region.

somes and the shortest ones (or those which are nearly so). In gemini of *S. cereale* also there was observed, as already stated a variation in their size, and in  $F_1$  both the bivalents and univalents showed a considerable size difference within themselves, which made it impossible to distinguish clearly the chromosomes derived from different parents from each other.

After the disjoined halves of bivalents passed to poles, all or most univalents were arranged at the equatorial region, where they were longitudinally split (Fig. 71).

Occasionally dyad pollen grains were produced.

### 3. *Aegilops ovata* $\times$ *Secale cereale*

In the cross *Ae. ovata* ( $n = 14$ ) (Fig. 72)  $\times$  *S. cereale* ( $n = 7$ ), 7  $F_1$  plants were raised. They grew rather poorly and were under 30 cm in height, each producing only few culms. The spikes of  $F_1$



72



73



74

Fig. 72. *Ae. ovata*, gemini. Side view.  $\times 1360$ . Figs. 73-74.  $F_1$  *Ae. ovata*  $\times$  *S. cereale*. First division, side views.  $\times 1360$ . 73,  $4_{II}+13_I$ ; 74,  $1_{III}+3_{II}+12_I$ .

were much smaller than those of *S. cereale* and rather approached those of *Ae. ovata* in size, though their shape was in main intermediate between the two parents.

In side views of first metaphase, usually 2-5 bivalents were found together with 17-11 univalents (Fig. 73). Trivalents were also frequently observed, but no more than one in a PMC (Fig. 74). The bivalents were of loose type as far as our observation goes, and in trivalents three elements were connected lengthwise. The diploid number of chromosomes was counted to be 21 as will be expected.

The gemini of *Ae. ovata* (Fig. 72) were observed generally to be smaller than those of *S. cereale* (Fig. 52), though the size difference could not be made out with certainty. Certain differences in size were found among the gemini of each species.

In  $F_1$ , as the variation of size was observed in both bivalents and univalents, it was impossible to identify the chromosomes derived from different parents, and it is probable that both autosynopsis of chromosomes derived from *Ae. ovata* and allosynopsis took place.

### III. Interspecific hybrids in *Aegilops*

#### 1. *Aegilops cylindrica* × *Aegilops speltoides*

One  $F_1$  plant was obtained by the cross *Ae. cylindrica* ( $n = 14$ ) × *Ae. speltoides* ( $n = 7$ ), where the somatic chromosome number was 21 in root tip cells (Fig. 75).

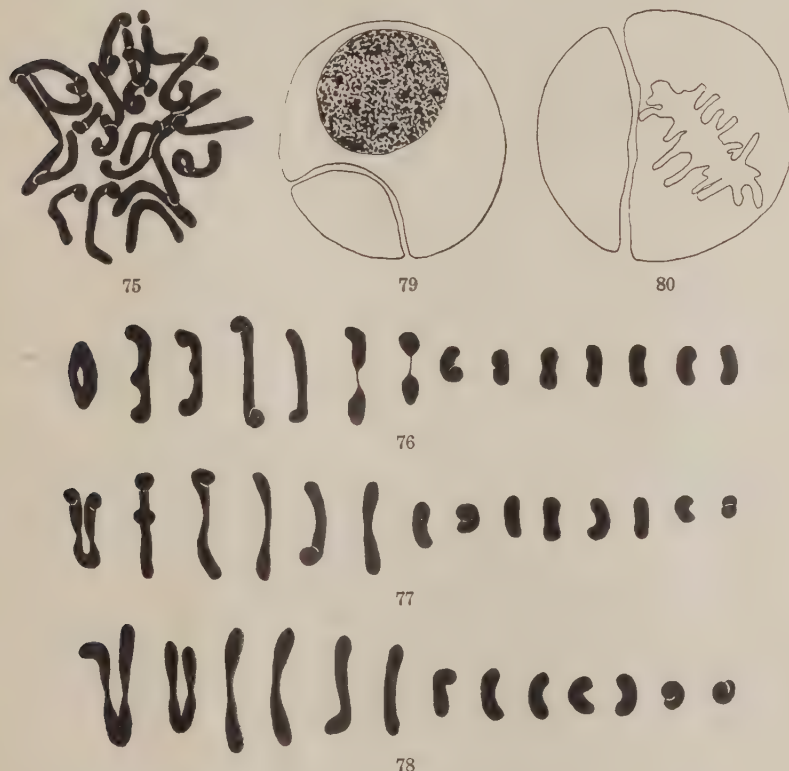
At first metaphase, bivalents and trivalents were observed besides univalents (Figs. 76, 77, 78), and the bivalents were usually of loose type, rarely ring-shaped (Fig. 76). The trivalents were composed of three chromosomes connected lengthwise presenting usually V shape. In most cases no more than one trivalent was found in a PMC, rarely their two sets, though often they were lacking.

The frequency of observing bivalents in a PMC was studied in 90 PMC-s containing bi- and univalents, in which precise observation of chromosomes was possible, though in many other PMC-s the chromosomes were arranged rather too compactly to allow their detailed studies. The results can be seen below:

Number of bivalents....	4	5	6	7	8	
Frequency .....	4	11	33	37	5	$n = 90$

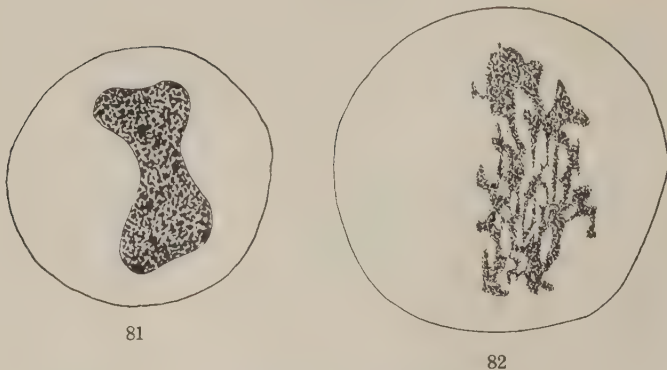
Rarely, all chromosomes were contained in one of the two cells formed by the cleavage furrow in first division (Fig. 79). Fig. 80

shows a second metaphase in such a cell. Here, the equational division of all chromosomes may possibly result in the formation of diploid pollen grains.



Figs. 75-80.  $F_1$  *Ae. cylindrica*  $\times$  *Ae. speltoides*. 75, 21 somatic chromosomes in root tip.  $\times 1900$ . 76-78, chromosomes of first division, side views.  $\times 1400$ . 76,  $7_{II} + 7_I$ ; 77,  $1_{III} + 5_{II} + 8_I$ ; 78,  $2_{II} + 4_{II} + 7_I$ ; 79, a nucleus in one of the 2 cells formed by cleavage furrow in first division: in the other cell no chromatic material is contained; 80, the stage following 79, metaphasic plate, side view. 79-80,  $\times 1400$ .

Often, the restitution nuclei were formed (Fig. 81), and Fig. 82 shows its early stage. From them also the production of diploid pollen grains is expected.



Figs. 81-82.  $F_1$  *Ae. cylindrica*  $\times$  *Ae. speltooides*. Side views.  $\times 1400$ . 81, restitution nucleus; 82, earlier stage of restitution nucleus formation.

## 2. *Aegilops cylindrica* $\times$ *Aegilops ovata*

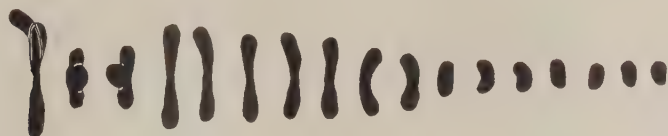
Cytological studies of  $F_1$  between *Ae. cylindrica* and *Ae. ovata* were already made by AASE (1930), PERCIVAL (1930) and KIHARA and LILIENFELD (1932). In our laboratory also the cross *Ae. cylindrica* ( $n=14$ )  $\times$  *Ae. ovata* ( $n=14$ ) was made and 27  $F_1$  plants were raised.

PERCIVAL (1930) reported that all the morphological characters of  $F_1$  *Ae. cylindrica*  $\times$  *Ae. ovata* agree closely with those of *Ae. triuncialis*, and he esteemed *Ae. triuncialis* to have been derived from the cross between *Ae. cylindrica* and *Ae. ovata*. The  $F_1$  plants of the writers showed also the spike characters very much resembling those of *Ae. triuncialis*.

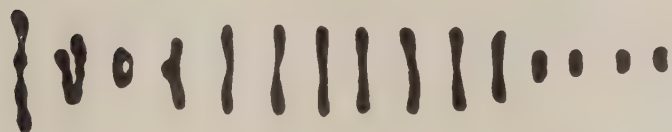
The precise observation of chromosome behaviours in  $F_1$  was not easy owing to the compact arrangement of chromosomes. PERCIVAL (1930) observed in  $F_1$  of the same parental combination 7-13 bivalents mostly of loose type. AASE (1930) found in her  $F_1$  3-8 bivalents, nearly three to one of the open type, and up to 4 trivalents most frequently V- or Y-shaped. She observed also the conjugation of more than 4 chromosomes. According to KIHARA and LILIENFELD (1932), the number of bivalents was 9-12, of which about one third was of the compact type. They observed also up to 3 tripartites.



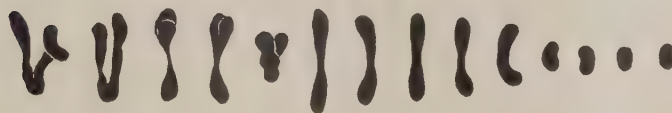
In our  $F_1$ , conditions resembling in main those found by AASE were observed. In first metaphase bivalents and trivalents appeared together with univalents (Figs. 83, 84, 85). The bivalents were usually of loose type, but occasionally ring-shaped. 6-9 bivalents were quite often met with in a PMC. The trivalents were very frequently seen, which were of the shape of V, Y or a straight rod and up to 4 such were detected in a PMC.



83



84



85



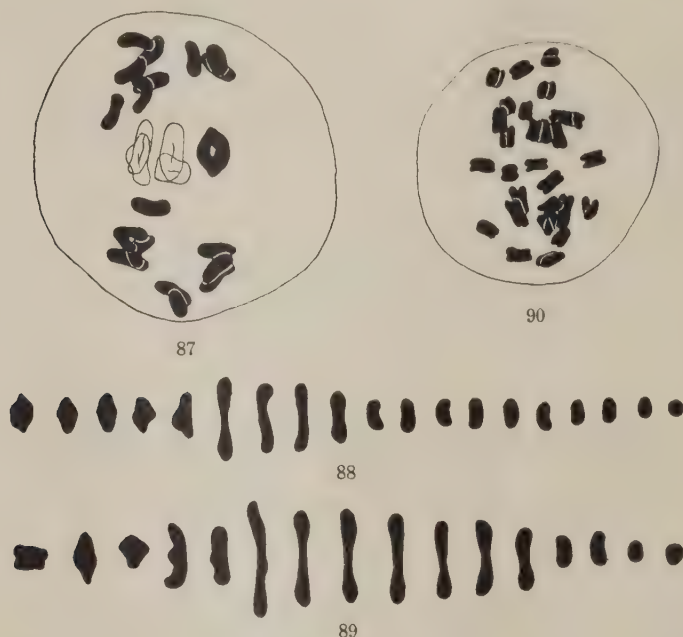
86

Figs. 83-86.  $F_1$  *Ae. cylindrica*  $\times$  *Ae. ovata*. Chromosomes of first division, side views.  $\times 1360$ . 83,  $1_{III}+9_{II}+7_I$ ; 84,  $2_{III}+9_{II}+4_I$ ; 85,  $4_{III}+6_{II}+4_I$ ; 86,  $1_V+9_{II}+5_I$ .

The diploid chromosome number of  $F_1$  was 28 as will be expected. Occasionally, more than three chromosomes were conjugated together to form a multipartite chromosome. The one shown in Fig. 86 must be formed by 5 chromosomes if considered from the number of other chromosomes in the PMC.

3. *Aegilops cylindrica* × *Aegilops ventricosa*

F<sub>1</sub> between *Ae. cylindrica* and *Ae. ventricosa* was studied cytologically by PERCIVAL (1930) and KIHARA and LILIENFELD (1932). We obtained 14 F<sub>1</sub> plants by the cross *Ae. cylindrica* (n=14) × *Ae. ventricosa* (n=14).



Figs. 87-90. F<sub>1</sub> *Ae. cylindrica* × *Ae. ventricosa*. Chromosomes of first division, side views. ×1360. 87, 5II+18I; 88, 9II+10I; 89, 12II+4I; 90, anaphase: chromosomes homotypically split, some on equatorial plane.

The observation of chromosomes was not also easy in this F<sub>1</sub> owing to their compact arrangement. In side views of first metaphase usually 6-10, occasionally 11-12 bivalents were observed besides univalents (Figs. 87, 88, 89). Among the bivalents usually 3-5 were ring-shaped or compact gemini, while the others were of loose type. In F<sub>1</sub> of the same combination of parents, PERCIVAL found 5-7 bivalents chiefly of loose type, and KIHARA and LILIENFELD observed 6-12 bivalents.

The diploid number of  $F_1$  was 28 as is expected. Some univalents were found at equatorial region after the disjoined halves of bivalents passed to poles (Fig. 90).

In some cases dyad cells were produced.

## Discussion

In recent years, the formation of amphidiploids was reported in different forms of plant. LEWITSKY and BENETZKAIA (1931) studied cytologically the constant intermediate hybrids between *T. vulgare* and *S. cereale*, the diploid chromosome number of which was 56, i.e. the number double that of  $F_1$ . The authors, however, did not consider as the formative cause of this amphidiploid form, the fusion of male and female  $F_1$  gametes containing the somatic number of chromosomes, in view of the lack of observation making clear the occurrence of non-reduction or the restitution nuclei formation in meiosis of the  $F_1$ .

But, considering the results of our observations on *T. compactum*  $\times$  *S. cereale*  $F_1$ , it is very probable that such phenomena may occur in meiosis of *T. vulgare*  $\times$  *S. cereale*  $F_1$ , resulting in the formation of constant intermediate hybrids in  $F_2$  generation. BLEIER (1930, a) reports also the possibility of forming an intermediate fertile form between *T. vulgare* and *S. cereale*. His Fig. 1, d shows the situation of chromosomes similar to that shown in our Fig. 7, in which almost all chromosomes are located at the equatorial region as univalents.

According to LEBEDEFF (1932), a new synthetical intermediate form was obtained between *T. vulgare* and *S. cereale*. It has arisen through the selfing of a plant formed by the union of unreduced gamete of  $F_1$  between these two species with the normal gamete of rye. It possesses 28 chromosomes in diploid, which were recognized to be composed of 14, the full somatic set of rye chromosomes and also 14 chromosomes from wheat.

These results indicate the existence of some different ways in combining the chromosomes of wheat and rye in a constant form. Intermediate hybrid forms which should possibly be raised between different species of wheat and rye must have no small significance from the view point of plant breeding. Namely, the useful characters of rye, for example, earliness, winter resistance, etc. may be combined in this way with the superior grain characters of wheat.

By our cross *T. compactum*  $\times$  *S. cereale*, the amphidiploid form is not yet produced. But the cytological processes that may result in the formation of diploid gametes, especially the formation of restitution nuclei were quite frequently observed in  $F_1$  meiosis. Thus, there is a great possibility of producing amphidiploid form in the next generation.

Many varieties of *T. compactum* are winter and drought hardy, and their resistance against parasitic fungi is also high. Moreover they may be cultivated well on poor soils, their yield and quality of grains being not unpromising. So that, if the amphidiploid form will be produced between them and *S. cereale*, it may be useful for practical purpose in some districts under special conditions of climate and soil.

Genetical and cytological studies on  $F_1$  of a number of combinations between *Triticum* species and rye which are now in progress in our laboratory will be reported in later papers.

Between species of *Triticum* and *Aegilops* each belonging to the tetraploid series, some amphidiploid forms were obtained by TSCHERMAK and BLEIER (1926), and KIHARA and KATAYAMA (1931). PERCIVAL (1930) also obtained fertile hybrids of similar nature between *Ae. ovata* and *T. turgidum*. Such forms may possibly be formed by the diploid gametes produced in  $F_1$ .

The equational division of all chromosomes as was observed in our *T. compactum*  $\times$  *S. cereale*  $F_1$  seems to occur not rarely in many  $F_1$ -s between *Triticum* and *Aegilops*. KAGAWA (1929, b), PERCIVAL (1930), AASE (1930) and KIHARA and KATAYAMA (1931) observed the figures indicating such possibility in a number of  $F_1$ -s between hexaploid or tetraploid species of *Triticum* and different tetraploid species in *Aegilops*.

The formation of restitution nuclei was observed also in  $F_1$ -s *T. durum*  $\times$  *S. cereale* and *Ae. cylindrica*  $\times$  *Ae. speltoides*, the feature often occurring in  $F_1$  between *Triticum* and *Aegilops*, as was reported for instance by KAGAWA (1929, b) and CHIZAKI (1932). KIHARA and KATAYAMA (1931) also observed the formation of restitution nuclei in *T. dicoccoides*  $\times$  *Ae. ovata*  $F_1$ , and considered that they may have played an important rôle for the production of their amphidiploid form.

In  $F_1$ -s of *T. compactum*  $\times$  *S. cereale*, *T. durum*  $\times$  *S. cereale* and *Ae. cylindrica*  $\times$  *Ae. speltoides*, occasionally all chromosomes were

distributed in first meiosis in one of the two cells formed by the cleavage furrow. Similar phenomena were observed by KAGAWA (1929, b) and AASE (1930) in  $F_1$ -s formed by different combinations of species between *Triticum* and *Aegilops*. The production of diploid pollen grains following the equational division which may occur in such a cell may not be excluded.

On the whole, however, it can be said that restitution nuclei are probably the most prevalent cause of producing diploid gametes which may result in the production of amphidiploid forms.

In our  $F_1$ -s in which the possible courses to form dyad cells or diploid pollen grains were not observed, the same phenomenon will certainly be detected if a larger amount of materials will be used for the study.

BLEIER (1930, b) observed in  $F_1$  *T. vulgare*  $\times$  *S. cereale* and in some genus hybrids between different species of *Aegilops* and *Triticum*, that two spindles are more or less frequently formed in a PMC in first division. And he recognized in his hypothesis of kryptogonomy that in one of the two spindles the chromosomes derived from one of the two parents, and in the other those derived from the other are chiefly contained. He observed also a long curved spindle in first metaphase, and recognized that it was probably composed of two spindles connected lengthwise.

AASE (1930) also observed in meiosis of different genus hybrids between *Aegilops* and *Triticum* the occurrence of figures showing more or less clearly the chromosome feature observed by BLEIER (1930, b). In PMC-s of genus hybrids among different species of *Aegilops* and *Triticum*, PERCIVAL (1930) reports that occasionally the parental chromosome groups are separated from each other in first division. The curved spindles were observed also by KIHARA and LILIENFELD (1932) in  $F_1$  *Ae. ventricosa*  $\times$  *T. aegilopoides* and by MATSUMOTO (1933) in  $F_1$  *Ae. ventricosa*  $\times$  *T. durum*.

BLEIER (1930, b) considered that two spindles are derived from paternal and maternal paragenoplast. However, KIHARA and LILIENFELD (1932) and MATSUMOTO (1933) recognized such two spindles to be the two arms of a single long spindle extremely curved. They did not observe that the parental chromosome groups are separated from each other in first division as was reported by BLEIER (1930, b).

Long curved spindles occasionally observed in our  $F_1$ -s *T. compactum*  $\times$  *S. cereale* and *T. durum*  $\times$  *S. cereale* were, under the consideration of their shape, always recognizable as one, not two spin-



dles, where the chromosomes were found distributed at random. Studies on the meiosis of  $F_1$  which will be formed between species having the chromosomes differing much from each other in their size may be useful in this respect.

The writers observed in  $F_1$  *T. compactum*  $\times$  *S. cereale* up to 3 bivalents, and up to 4 in  $F_1$  *T. Spelta*  $\times$  *S. cereale*. This can be explained by the hypothesis of KIHARA and NISHIYAMA (1930) that up to 3 bivalents may be formed between A and B genoms and also between B and D genoms of *Triticum*. On the other hand the writers observed in *T. durum*  $\times$  *S. cereale*  $F_1$  up to 5 bivalents. This number exceeds that of bivalents expected from the above hypothesis to be formed among the chromosomes derived from A and B genoms of *T. durum*. The conjugation may have occurred allosyndetically between chromosomes of *T. durum* and *S. cereale*.

KIHARA and LILIENFELD (1932) proposed, from the studies of species hybrids in *Aegilops* and genus hybrids of *Triticum* and *Aegilops*, that the highest number of chromosome conjugation may be 4 between two genoms of *Ae. triuncialis*, and 2 between two genoms of *Ae. cylindrica* and of *Ae. ovata*.

The highest number of bivalents which we observed was 7 in *Ae. triuncialis*  $\times$  *S. cereale*  $F_1$  and also in *Ae. cylindrica*  $\times$  *S. cereale*  $F_1$  and 5 in *Ae. ovata*  $\times$  *S. cereale*  $F_1$ . In *Ae. cylindrica*  $\times$  *Ae. speltoides*  $F_1$  we observed up to 8 bivalents. In all these  $F_1$ -s, a certain number of trivalents were also observed. In chromosomes of these tetraploid *Aegilops* species conjugation might have occurred more frequently than in KIHARA and LILIENFELD's cases; or allosyndesis between chromosomes of these tetraploid *Aegilops* species and *S. cereale* and that between *Ae. cylindrica* and *Ae. speltoides* might have taken place.

As to the causes to form loose bi- and trivalents as well as the bi-, tri- and multipartite chromosomes, the translocation among different chromosomes may be taken into consideration.

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# The relation between the absorption of water by plant root and the concentration and nature of the surrounding solution

By Takashi TAGAWA

(Contribution from the Botanical Institute, Faculty of Agriculture,  
Hokkaido Imperial University, Sapporo, Japan)

With 11 figures and 20 tables

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## Introduction

According to general opinion water absorption by the plant is explained by theories based on the osmosis of living cells. STILES (1924) showed this relation by the following formula:

$$S = P - P_e - T$$

where  $P$  is the osmotic pressure of the cell sap in the vacuole,  $P_e$  the osmotic pressure of the surrounding solution,  $T$  the inwardly directed pressure exerted by the cell wall, and  $S$  the net suction force.

Finding the lineal graphical relation between the amount of water absorbed by the plant root and the concentrations of surrounding solutions, BRIEGER (1928) attempted to explain the water absorption by the following formula:

$$A = k (S - R^a)$$

where  $A$  is the amount of water absorbed,  $S$  the suction force of the root cell,  $R^a$  the external friction and  $k$  the constant.

LACHENMEIER (1932) suggested that the transpiration affects the absorption by the root system, and KRAMER (1932, 1933) came to the conclusion that the rôle, which the plant root plays in the absorption of water, had been greatly over-emphasized. In fact the plant root plays an active part only when little or no transpiration occurs. According to this opinion, therefore, the root of an active-transpiring plant is important only as absorbing surface.

As one can not neglect the influence of transpiration on the water absorption, it is very important that the problem of the water absorption by the root should be considered only after experiments have been made under constant conditions of the milieu, that is, when temperature, light and relative humidity of the air and the solution respectively are kept constant.

The experiments reported in the present work were conducted chiefly with the following objects:

1. The determination of the quantitative relation between the water absorption and the concentration of surrounding solution.
2. The influence of solutes on the water absorption.

## Method and material

### 1. *Apparatus*

In the experiments it is necessary to take into consideration the influence of the external conditions which affect the related physiological functions such as transpiration, ascent of sap etc. So far as the writer is aware, experiments of this kind have hitherto been carried out with scarcely sufficient consideration for such matters. BRIEGER (1928) directed his attention especially to keep constant the temperature of the solutions in which the plant roots were immersed, but artificial regulation of the relative humidity was not carried out.

The influence of light on the change of the osmotic value of plant cells was investigated by DE VRIES (1884) and BÄCHER (1919), and such influence on plasma permeability was confirmed by LEPESCHKIN (1909) and TRÖNDLE (1910). LIVINGSTON (1910) studied the quantitative relation between light intensity and transpiration, and his results showed the remarkable accelerating influence of the sunshine upon the rate of water loss by a green plant.

For several reasons it is very probable that the increase of transpiration causes the increase of water absorption by the plant root, as suggested by KRAMER (1932, 1933) and LACHENMEIER (1932).

In the present work the temperature of the solution as well as of the atmosphere, the relative humidity and the light intensity were treated as the most important factors and special attention was

given to keeping them constant. In order to avoid the influence of light on the water absorption by the plant root the experiments were conducted in a cool dark room under the constant illumination of a 200 Watt Mazda-Lamp (A in Fig.1). The material and the water bath (B in Fig.1) were enclosed together in a glass chamber of  $45 \times 45 \times 50$  cm (C in Fig.1). At the lower part of each side an opening of about 3 cm. height was made through which wet air could be driven out.

The amount of water absorbed by a plant root was determined by means of a potometer modified by the writer. As shown in Fig. 1 the glass vessel (D) was closed with a caoutchouc stopper

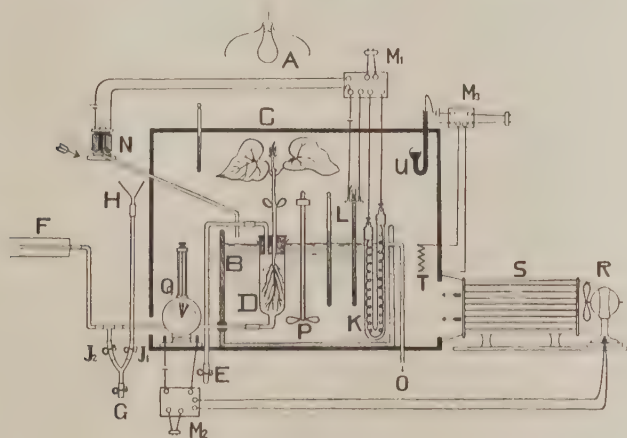


Fig. 1

which had two holes and the caoutchouc wall of one of them was slitted lengthways from end to end. The stem was covered with cotton and KAHLBAUM cock grease and fastened in the hole through the vertical slit. In the other hole a L-shaped glass tube was inserted and connected with the outlet tube (E). The lower opening of the vessel was connected with a Y-shaped glass tube and the graduated potetometer tube. One of the branches of the Y-tube ( $J_1$ ) was connected with a glass funnel (H) and the tube G served as an outlet. The connecting rubber tube of each branch of this Y-tube was closed with a pinch cock during the experiment. The solution in the vessel was newly supplied or replaced easily without



any disturbance, keeping the plant fixed in the potetometer. At first the pinch cocks,  $J_1$ ,  $J_2$  and E were opened and the solution was poured through the funnel H into the vessel D without allowing any air bubble to form in it. When the potetometer was filled up with solution, overflow came out from the outlet E. After the outlet E was closed with a pinch cock, then overflow came out from the end opening of the calibrated tube F. After the absence of any air bubble in the potetometer was ascertained, the pinch cocks  $J_1$  and  $J_2$  were closed, and the apparatus was ready for the experiment. From the retirement of the water meniscus in the calibrated tube, the diameter of which was 1 mm., the amount of water absorbed could be determined and expressed relatively by the number of the calibration. In order to discharge the solution after the experiment, all pinch cocks were opened and the solution flowed quickly out of the lower outlet (G). By this operation it was possible to replace the whole solution in about three minutes. As even the more slightly influence of temperature on the water absorption by the root should be rightly and properly considered, the larger part of the potetometer was immersed in the water bath (B) and the volume change of solution in the calibrated tube, caused by the temperature fluctuation, was regarded practically as negligible. The temperature of the water bath was kept at  $21^\circ \pm 0.1^\circ\text{C}$  throughout the whole course of the experiments, by using the electric heater (K), the regulator (L) and relay ( $M_1$ ). The regulation of the water temperature was further facilitated by the in- and outflow of tap water which was automatically realized by starting and shutting off a water stream by means of a magnetic apparatus (N) which operated with the double action of the relay  $M_1$ . A stirrer (P) was used also in order to help keep the temperature in the water bath constantly uniform. The prepared solution was immersed in the water bath kept in an ERLNMYER flask for at least 20 minutes before its application. In this way the temperature of the solution in the vessel D was maintained always equal to that of the surrounding water ( $21^\circ\text{C}$ ). The relative humidity in the glass chamber was regulated to 60% with an automatic humidity regulator (Q) made by the Institute of Physical and Chemical Research, Tokyo. When the humidity rises above 60% the electric current of a storage battery is closed by the contact of the compass-needle with the compass-rod of this regulator and the relay ( $M_2$ ) acts causing the rotation of the electric fan (R). The air which

is dried during the passing through the dryer (S), is sent into the glass chamber through the lower opening without striking the plant directly. When the relative humidity is restored to 60%, the electric current is cut off automatically and the air movement ceases. The fluctuation of the relative humidity in this glass chamber was about  $\pm 0.3\%$ .

In order to keep a constant relative humidity, the temperature of air should not be neglected, because the two of them stand in a reciprocal relation to each other, that is, the increase of the air temperature is accompanied by the lowering of the relative humidity. To keep a constant air temperature of  $28^{\circ}\text{C}$  in this glass chamber an electric heater (T), a regulator (U), and a relay ( $M_3$ ) were used. The fluctuation of the air temperature was about  $\pm 0.5^{\circ}\text{C}$ .

## 2. Potetometer solution

The distilled water was treated with KAHLBAUM's blood charcoal in order to remove copper and other oligodynamically toxic substances. Any air dissolved in distilled water thus treated was drawn out using a vacuum pump. This was necessary to avoid development of any air bubble in the vessel during the experiment, which would disturb the procedure.

The solutions<sup>(1)</sup> used in the present work are shown in Table 1 and their osmotic value were indicated by the depression of the freezing point ( $\Delta$ ).

TABLE 1

Conc. in Vol-Mol.	1/10	1/20	1/40	1/80	1/160	1/320	1/640
Solutions							
$\text{CaCl}_2$	0.154	0.088	0.042	0.022	0.014	0.005	0.003
KCl	0.198	0.106	0.052	0.023	0.014	0.008	0.003
$8\text{K}+2\text{Ca}$	0.191	0.093	0.058	0.030	0.013	0.007	0.003
$2\text{K}+8\text{Ca}$	0.163	0.078	0.045	0.026	0.011	0.007	0.003
Sucrose	0.200	0.100	0.049	0.023	0.014	0.007	0.003

(1) The solutions were prepared in the volume molar concentration. The osmotic value calculated from the concentration and the freezing point depression was found out in the table of URSPRUNG and LEWIS respectively.

The experiments were carried out not only with single salt solution, but with salt mixtures and the KNOP solution, the latter of which can be regarded as a complete nutrient and physiologically balanced salt solution. Its composition is as follows:

Original solution	MgSO <sub>4</sub> 7H <sub>2</sub> O	2.5 g.
	KH <sub>2</sub> PO <sub>4</sub>	2.5 g.
	KCl	1.2 g.
	Ca(NO <sub>3</sub> ) <sub>2</sub>	10 g.
	FeCl <sub>3</sub> (2%)	one drop
	tap water	1000 cc. <sup>(1)</sup>
	$\Delta$	= 0.370

The  $\Delta$  values of KNOP solution in varied concentrations are shown in Table 2.

TABLE 2

No. of Sol.	1	2	3	4	5	6	7
Orig. sol. (cc.)	200	150	100	50	25	15	3
Water (cc.)	170	220	270	320	345	355	367
$\Delta$	0.215	0.170	0.120	0.06	0.03	0.018	0.003

### 3. Plant material

The materials used were young seedlings of *Phaseolus vulgaris* germinated in sawdust watered with tap water, and each of them was cultured 10–14 days before the experiment in a porcelain pot with tap water in the green house. A healthy material with well developed side roots was brought into the laboratory early in the morning and fixed in the potometer as described above.

STOPPEL (1916) and STERN and BÜNNING (1929) studied the daily periodical movement of leaves of *Phaseolus multiflorus*. The last named two authors have explained that this periodical movement was caused by the daily fluctuation of the air temperature. As it is very possible that this movement is intimately related to the depression of water absorption by the root, no sooner was any sign of this movement recognized than the experiment was stopped.

(1) For the preparation of KNOP solution fresh tap water was used instead of distilled water.

## Experiments

In each experiment it is necessary to determine the amount of water absorbed by a plant root immersed in distilled water, which serves as the control to the absorption from solutions of varied concentrations. When the water or solution surrounding the root was replaced by another solution having a higher osmotic value, the amount of water absorbed by the plant root varies with the lapse of time. RENNER (1912, 1929), MONTFORT (1922) and BRIEGER (1928) have studied this problem and this change of water absorption from new solution was called by BRIEGER (1928) transference reaction (Ueberführungsreaktion). RENNER (1912) concluded that if the new solution has a higher osmotic value, the water absorption suddenly decreases and then increases gradually, and that if it is of a lower osmotic value, the water absorption suddenly increases and then decreases gradually.

MONTFORT (1922) ascertained that if a culture solution was replaced by the same culture solution plus 1% (— 0.09 GM.)  $\text{CaCl}_2$ , the amount of water absorbed gradually decreased and the minimum constant value was reached in two or three hours after the transference. After careful experiments BRIEGER (1928) came to results agreeing with those of RENNER.

The most important consideration in the experiment on the transference reaction is when or how long the measurement of the water absorption after the transference should be carried out. With regard to this problem preliminary experiments with intact plants were made<sup>(1)</sup>. The measurement was made at the end of every ten minute period after the transference; the values of three measurements were averaged and the mean value was expressed in percentage. The average volume of water absorbed from pure water, in one hour was taken as 100.

Sucrose, KCl,  $\text{CaCl}_2$ , and KNOP solution in various concentrations were used. The results are shown in Tables 3-6 and Fig. 2.

As seen from the above tables and figure, the transference reaction varies according to the difference of the nature and concentration of the solution. The most remarkable fact is, that the

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(1) The transference reaction of a decapitated plant will be shown in a later chapter.

TABLE 3  
Sucrose solution

Dist. water			Dist. water		
Ten minute periods	Amount of water absorbed	%	Ten minute periods	Amount of water absorbed	%
1	1.50	100.0	1	0.60	100.0
2	1.15		2	0.85	
3	0.80		3	0.85	
4	0.75		4	0.75	
5	0.60		5	0.75	
6	—		6	0.75	
Solution ( $\Delta = 0.200$ )			Solution ( $\Delta = 0.200$ )		
1	0.35	43.5	1	0.30	35.5
2	0.35		2	0.25	
3	0.45		3	0.25	
4	0.40	62.8	4	0.30	42.1
5	0.50		5	0.30	
6	0.40		6	0.35	
7	0.45	77.3	7	0.30	42.1
8	0.45		8	0.35	
9	0.45		9	0.30	
10	0.50	82.1	10	0.30	42.1
11	0.40		11	0.35	
12	0.45		12	0.30	
Dist. water			Dist. water		
Ten minute periods	Amount of water absorbed	%	Ten minute periods	Amount of water absorbed	%
1	0.20	100.0	1	1.45	100.0
2	0.20		2	1.10	
3	0.35		3	0.90	
4	0.15		4	0.80	
5	0.30		5	0.80	
6	0.50		6	—	
Solution ( $\Delta = 0.003$ )			Solution ( $\Delta = 0.003$ )		
1	0.30	89.3	1	1.00	92.4
2	0.25		2	0.90	
3	0.20		3	0.90	
4	0.25	83.3	4	0.80	82.5
5	0.25		5	0.90	
6	0.20		6	0.80	
7	0.25	77.4	7	0.80	79.2
8	0.20		8	0.85	
9	0.20		9	0.75	
10	0.15	59.5	10	0.80	75.9
11	0.15		11	0.80	
12	0.20		12	0.75	



TABLE 4  
KCl solution

Dist. water			Dist. water		
Ten minute periods	Amount of water absorbed	%	Ten minute periods	Amount of water absorbed	%
1	0.25	100.0	1	0.60	100.0
2	0.35		2	0.50	
3	0.30		3	0.50	
4	0.30		4	0.45	
5	0.40		5	0.50	
6	0.40		6	0.50	
Solution ( $\Delta = 0.198$ )			Solution ( $\Delta = 0.198$ )		
1	0.15	40.4	1	0.10	33.3
2	0.15		2	0.10	
3	0.10		3	0.30	
4	0.15	45.5	4	0.15	33.8
5	0.15		5	0.20	
6	0.15		6	0.15	
7	0.10	40.4	7	0.15	53.8
8	0.15		8	0.35	
9	0.15		9	0.30	
10	0.15	50.5	10	0.40	73.3
11	0.20		11	0.30	
12	0.15		12	0.40	
Dist. water			Dist. water		
Ten minute periods	Amount of water absorbed	%	Ten minute periods	Amount of water absorbed	%
1	0.30	100.0	1	0.40	100.0
2	0.30		2	0.35	
3	0.30		3	0.30	
4	0.35		4	0.40	
5	0.25		5	0.40	
6	0.30		6	0.35	
Solution ( $\Delta = 0.003$ )			Solution ( $\Delta = 0.003$ )		
1	0.35	94.4	1	0.30	86.4
2	0.25		2	0.30	
3	0.25		3	0.35	
4	0.25	90.0	4	0.35	86.4
5	0.25		5	0.30	
6	0.30		6	0.30	
7	0.25	94.4	7	0.35	86.4
8	0.30		8	0.30	
9	0.30		9	0.30	
10	0.30	100.0	10	0.20	71.1
11	0.30		11	0.40	
12	0.30		12	0.20	

TABLE 5  
CaCl<sub>2</sub> solution

Dist. water			Dist. water		
Ten minute periods	Amount of water absorbed	%	Ten minute periods	Amount of water absorbed	%
1	0.80	100.0	1	0.65	100.0
2	0.75		2	0.60	
3	0.65		3	0.65	
4	0.65		4	0.65	
5	0.65		5	0.60	
6	0.65		6	0.65	
Solution ( $\Delta = 0.154$ )			Solution ( $\Delta = 0.154$ )		
1	0.08	43.5	1	0.25	31.9
2	0.32		2	0.20	
3	0.50		3	0.20	
4	0.50	62.8	4	0.40	53.1
5	0.35		5	0.35	
6	0.45		6	0.35	
7	0.60	77.3	7	0.35	53.1
8	0.50		8	0.40	
9	0.50		9	0.35	
10	0.60	82.1	10	0.35	53.1
11	0.55		11	0.40	
12	0.55		12	0.35	
Dist. water			Dist. water		
Ten minute periods	Amount of water absorbed	%	Ten minute periods	Amount of water absorbed	%
1	0.65	100.0	1	0.60	100.0
2	0.60		2	0.55	
3	0.60		3	0.55	
4	0.60		4	0.50	
5	0.60		5	0.55	
6	0.55		6	0.55	
Solution ( $\Delta = 0.003$ )			Solution ( $\Delta = 0.003$ )		
1	0.65	97.3	1	0.45	81.8
2	0.60		2	0.45	
3	0.50		3	0.45	
4	0.45	75.0	4	0.45	87.9
5	0.40		5	0.50	
6	0.50		6	0.50	
7	0.50	75.0	7	0.55	96.9
8	0.40		8	0.55	
9	0.45		9	0.45	
10	0.45	72.2	10	0.50	90.9
11	0.40		11	0.55	
12	0.45		12	0.45	

water absorption from diluted KNOP solution exceeded that from pure water about one hour after the transference. Generally speaking, in the concentrated solutions the water absorption by an intact plant decreased suddenly at once after the transference and then increased gradually to the constant values. This is in accord with the results of RENNER (1912) and BRIEGER (1928). In the dilute solutions the reaction process did not take place uniformly. In KCl solution the reaction progressed as in the concentrated solution, while in the sucrose and  $\text{CaCl}_2$  solutions the water absorption

TABLE 6  
KNOP solution

Dist. water			Dist. water		
Ten minute periods	Amount of water absorbed	%	Ten minute periods	Amount of water absorbed	%
1	1.87	100.0	1	1.20	100.0
2	1.70		2	1.15	
3	1.55		3	1.10	
4	1.45		4	1.10	
5	1.45		5	1.10	
6	1.40		6	1.05	
Solution ( $\Delta = 0.215$ )			Solution ( $\Delta = 0.003$ )		
1	0.70	47.7	1	0.90	86.3
2	0.70		2	0.90	
3	0.85		3	1.10	
4	0.85	58.4	4	1.20	104.2
5	0.90		5	1.10	
6	1.00		6	1.20	
7	1.00	61.6	7	1.15	101.2
8	0.90		8	1.15	
9	1.00		9	1.10	
10	0.90	63.7	10	1.10	86.3
11	1.10		11	0.85	
12	1.00		12	0.95	
13	0.95	60.5	13	0.95	81.8
14	0.95		14	0.90	
15	0.95		15	0.90	
16	0.90	57.3	16	0.90	75.9
17	0.90		17	0.85	
18	0.90		18	0.80	

decreased gradually to the minimum value as described by MONTFORT (1922). In the KNOP solution the increase of water absorption first occurred and then a gradual depression was recognized.

From Fig. 2 it will be seen that the maximum water absorption may be reached at least in one hour after transference of the solu-

tion. Accordingly in the present work the mean value of water absorption from each solution during one hour after the transference was determined and expressed in percentage, while the value in the case of pure water was taken as 100.

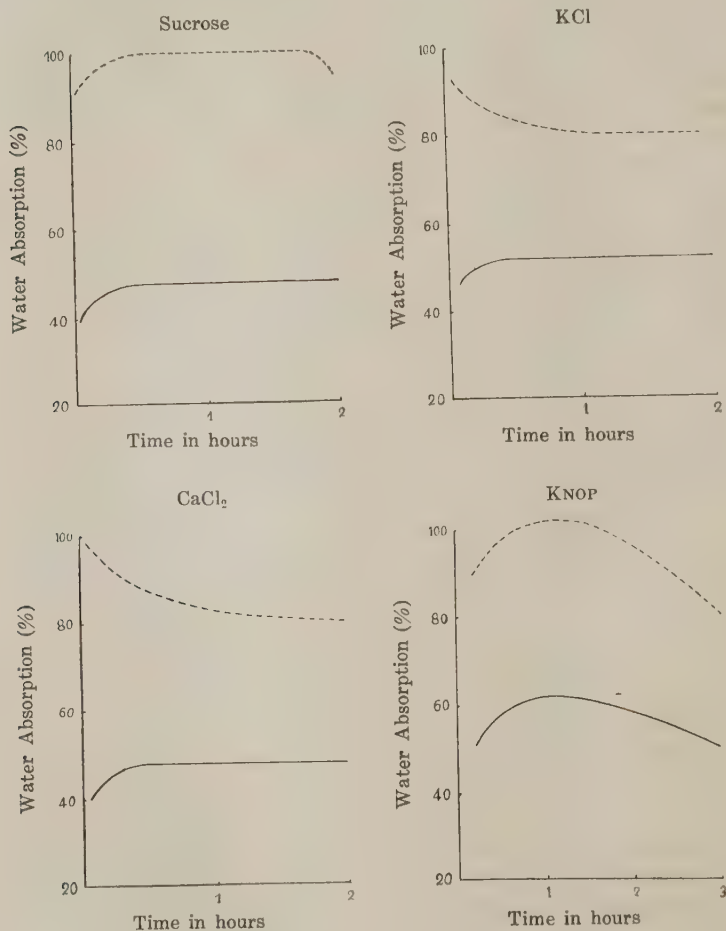


Fig. 2 (The figures are shown diagrammatically)

— relatively concentrated solutions  
 - - - - - relatively dilute solutions

In the experiment on the water absorption by the plant root the following forces can be taken into consideration as probable:

1. The suction force of living root cells caused by osmosis.
2. The suction force of the top developed by transpiration.
3. Several factors in the conducting or other tissues, retarding the water transport.

In order to analyze these relations, experiments were conducted in the following two ways:

Part A. With intact plants.

Part B. The plant shoot was decapitated with a sharp razor at the base of the epicotyle.

- (a) The stump was covered with wet cotton.
- (b) The stump was connected with a vacuum pump and sucked under a constant low pressure of 20 cm. mercury height regulated with an automatic manometer.

#### PART A WITH INTACT PLANT

It is the general opinion that protoplasm is almost semipermeable for sugar and relatively permeable for some electrolytes. So it is desirable, in the first part of the experiment, to ascertain the relation between the concentration of solution and amount of water absorbed by plant root using relatively hard penetrable sugar solution.

The penetrabilities of electrolytes are different from each other according to their nature. HANSTEEN-CRANNER (1914) found that  $\text{CaCl}_2$  acts unfavourably upon water retention in a plant body, retarding the water absorption by the root and accelerating the water loss from leaves, but that  $\text{KCl}$  seems to have power to accelerate the absorption of water and to retard its loss by transpiration. The same results were obtained by REED (1910) and KISSER (1927).

In the following experiments the different actions of various solutions on the water absorption were studied comparatively and the action of the mixture of two kinds of solute, namely K plus Ca, and of KNOP solution were also taken into consideration, the latter of which can be regarded physiologically as well as nutritively as a complete solution.



## Experiment 1. Sucrose solution.

TABLE 7

$\Delta$ Water absorption (%)	0.200	0.140	0.100	0.049	0.023	0.014	0.007	0.003
1	56.1	42.3	38.8	56.3	87.9	85.1	68.4	86.4
2	44.8	41.1	60.6	93.3	77.8	77.8	94.4	88.4
3	38.3	48.9	42.1	53.8	68.2	94.9	91.9	87.5
4	24.1	45.2	41.0	66.7	92.5	78.8	94.4	87.7
5	38.4	—	56.3	62.5	73.5	77.5	86.1	88.9
Mean value	40.3	44.4	47.5	66.5	77.7	32.8	87.0	87.8

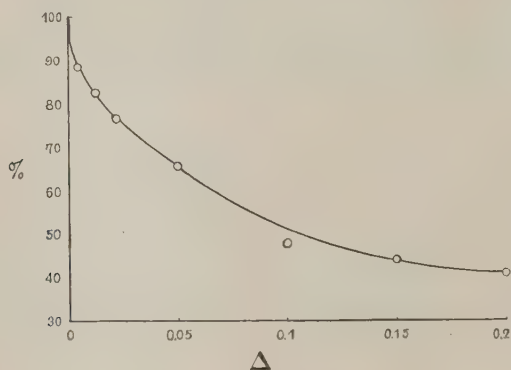


Fig. 3 Sucrose solution

Experiment 2.  $\text{CaCl}_2$  solution.

TABLE 8

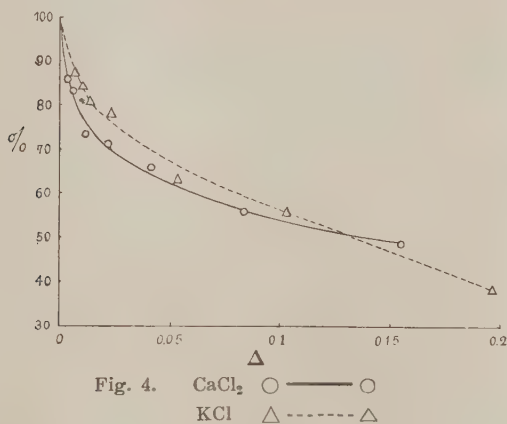
$\Delta$ Water absorption (%)	0.154	0.088	0.042	0.022	0.014	0.005	0.003
1	53.1	59.1	66.7	83.7	69.1	83.3	86.7
2	46.0	56.3	66.9	59.3	77.3	84.8	85.5
Mean value	49.6	57.7	66.8	71.5	73.2	84.1	86.6

## Experiment 3. KCl.

TABLE 9

Water absorption (%) \ $\Delta$	0.198	0.106	0.052	0.023	0.014	0.008	0.003
1	42.9	63.2	67.1	73.9	85.4	79.4	86.4
2	33.3	47.1	60.6	83.3	75.1	88.2	87.6
Mean value	38.2	55.2	63.8	78.6	80.3	83.8	86.9

These experimental data are illustrated in Fig. 4.



## Experiment 4. Mixture solution.

a) 8 parts KCl + 2 parts  $\text{CaCl}_2$

TABLE 10

Water absorption (%) \ $\Delta$	0.191	0.093	0.058	0.030	0.013	0.007	0.003
1	48.7	60.2	73.8	82.1	—	95.0	87.1
2	57.1	53.7	60.9	59.7	78.2	78.4	89.8
Mean value	52.9	59.5	67.3	70.9	78.2	86.7	88.5

b) 2 parts KCl+8 parts CaCl<sub>2</sub>

TABLE 11

$\Delta$ Water absorption (%)	0.163	0.078	0.045	0.026	0.011	0.007	0.003
1	26.0	47.6	42.5	63.8	79.4	82.3	84.6
2	52.0	49.3	72.6	67.8	89.5	76.8	81.9
Mean value	39.0	48.5	57.5	65.2	84.5	79.6	83.3

Experiment 5. KNOP solution.

TABLE 12

$\Delta$	0.213	0.165	0.115	0.076	0.045	0.025	0.0025
Water absorption (%)	53.1	62.8	74.6	77.4	85.5	84.1	96.1

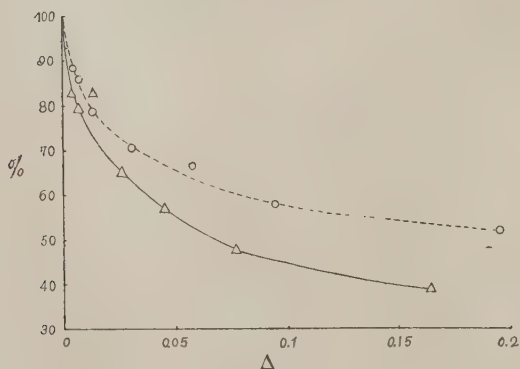


Fig. 5    8 K + 2 Ca    ○ ——— ○  
              2 K + 8 Ca    △ ——— △

As seen from the experimental data stated above, the water absorption by plant root does not show any simple proportional relation to the concentration of surrounding solution such as reported by BRIEGER (1928). That the amount of water absorbed was less

in the more concentrated solutions is beyond question. However, in the diluted solutions any dilution of a slight degree caused a remarkable decrease of the water absorption, while the differences of water absorption among concentrated solutions were not remarkable, compared with differences in the concentration of the solutions. It is very noticeable that the total amount of water absorbed by the intact plant root from a solution of hard penetrable sucrose is almost the same as that from a solution of penetrable KCl.

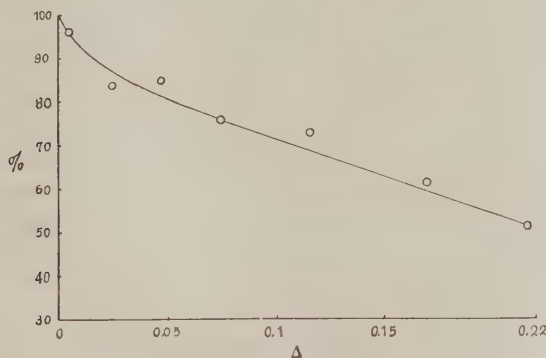


Fig. 6 KNOP solution

It is noteworthy that the intact plant stopped water absorption for 20 minutes after the transference from distilled water into a sucrose solution of  $\Delta = 1.22$  and then again the water absorption began. But this secondary water absorption seems to be abnormal phenomenon, because the osmotic value of the root epidermis 4.22 atm. ( $\Delta = 0.33$ ) determined by the vapour pressure methode of BARGER-ERRERA is lower than that of the surrounding sucrose solution  $\Delta = 1.22$  and several abnormal symptoms appeared. The root which had been milky white before the experiment, became dark semi-transparent, and microscopical examination showed that the epidermal cells were killed. Under these conditions the root system acts only as an absorbing filter surface. In a more concentrated solution than  $\Delta = 1.22$ , the roots lost water into the surrounding solutions soon after the transference and again the secondary abnormal water absorption was also recognized.

If Ca retards the absorption of water by plant root as suggested by HANSTEEN-CRANNER (1924) and KISSER (1927), it might be expected that the amount of water absorbed would decrease with the increase of Ca-content and vice versa. In the present work with the intact plant, as shown in Exp. 4, it was found also that the amount of water absorbed from the mixture (8 parts KCl + 2 parts  $\text{CaCl}_2$ ) of varied concentrations always exceeded that from the mixture (2 parts KCl + 8 parts  $\text{CaCl}_2$ ). Furthermore as seen from Fig. 5 the difference in amount of water absorbed between these mixtures of two different ratios became more remarkable in parallel to the increase of concentration. It is very interesting that the action of K and Ca on the water absorption by plant root was more striking in mixture than in their single solution. That is, the amount of water absorbed from the mixture (8 parts KCl + 2 parts  $\text{CaCl}_2$ ) was the largest among the solutions used in the above experiments, but on the contrary that from the mixture (2 parts KCl + 8 parts  $\text{CaCl}_2$ ) was the smallest. From this fact it may be said that the water absorption by plant root from a mixture solution of suitable composition and ratio can be increased over that from a single solution.

In the experiment with the KNOP solution (Fig. 6) the curve of the water absorption shows almost a straight line, with the exception of the extremely diluted solution. The water absorption from KNOP solution, therefore, showed almost inversely proportional to the concentration of the surrounding solution, and it is of special interest that the total amount of water absorbed from KNOP solution was clearly much greater than that from any others. This might be somewhat expected from the fact that the amount of water absorbed from a salts mixture of favourable ratio and dosis is greater than that from a single solution as shown in Exp. 4. This is explained by the assumption that in KNOP solution, a physiologically well balanced solution, the cell condition is very favourable for the water absorption.

## PART B WITH DECAPITATED PLANT

LACHENMEIER (1932) pointed out the influence of transpiration on the water absorption by plant root and KRAMER (1932, 1933) came to the conclusion that the root of an actively transpiring plant is important only as an absorbing filter surface for mechanical water



absorption according to the suction force of the shoot. It is a very important problem to see whether the significance of the function of the root in water absorption is limited as stated above. If this function of the root should be regarded as of much importance, the water absorption of the decapitated plant could occur in a not remarkably decreased degree.

The experiments in Part B were carried out with the same solutions as in Part A.

Generally speaking the maximum amount of water absorbed by the decapitated plant root was recognized for one hour after the transference from pure water into a solution of varied concentration followed by a gradual decrease to the minimum value.

#### Experiment 6. Sucrose solution.

TABLE 13

The shoot was removed at the base of the epicotyle and the stump was connected with a vacuum pump and sucked under the constant low pressure of 20 cm. mercury height.

$\Delta$	0.200	0.165	0.160	0.150	0.140	0.100	0.050	0.023	0.014	0.007	0.003
Water absorption (%)	-14.5	-11.5	-0.1	3.3	16.4	29.6	33.4	51.4	51.7	62.4	84.0

TABLE 14

The shoot was removed at the base of the epicotyle and the stump was covered with wet cotton.

$\Delta$	0.200	0.165	0.160	0.150	0.140	0.100	0.050	0.023	0.014	0.007	0.003
Water absorption (%)	-36.6	-20.0	-4.4	10.9	13.7	25.0	40.9	53.3	53.0	54.8	74.4

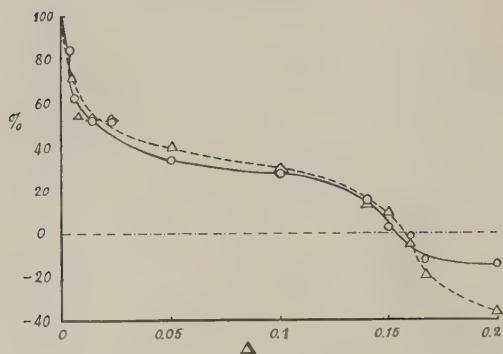


Fig. 7. Sucrose solution

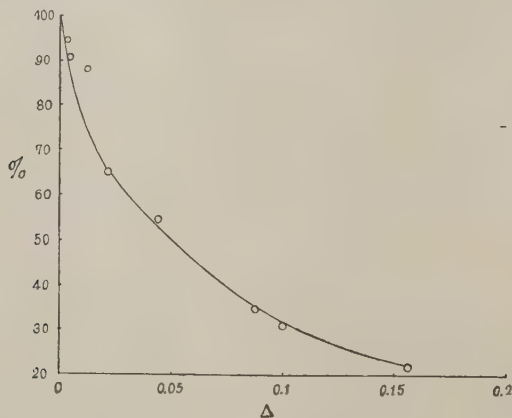
○ — ○ treated with vacuum pump  
 △ - - - △ untreated

Experiment 7.  $\text{CaCl}_2$  solution.

TABLE 15

The shoot was removed at the base of the epicotyle and the stump was covered with wet cotton,

$\Delta$	0.154	0.100	0.088	0.042	0.022	0.014	0.005	0.003
Water absorption (%)	23.3	31.5	35.3	55.3	65.3	89.2	92.3	95.7

Fig. 8.  $\text{CaCl}_2$  solution

## Experiment 8. KCl.

TABLE 16

The shoot was removed at the base of the epicotyle and the stump was connected with a vacuum pump and sucked under the constant low pressure of 20 cm. mercury height.

$\Delta$	0.198	0.106	0.052	0.023	0.013	0.008	0.003
Water absorption (%)	28.9	46.6	54.4	60.3	65.5	82.2	104.8

TABLE 17

The shoot was removed at the base of the epicotyle and the stump was covered with wet cotton.

$\Delta$	0.198	0.145	0.106	0.052	0.023	0.013	0.008	0.003
Water absorption (%)	29.5	40.0	51.1	56.5	69.1	75.6	87.0	89.6

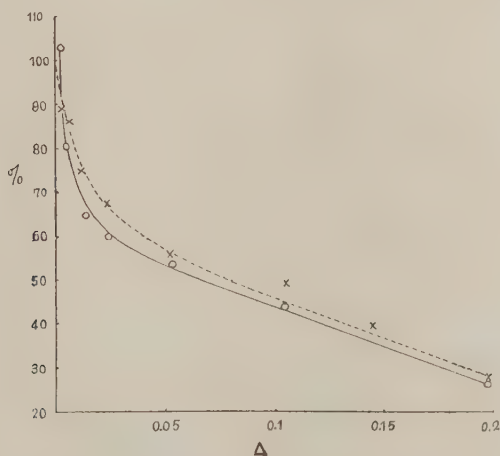


Fig. 9. KCl solution

○ — ○ treated with vacuum pump  
 × - - - × untreated.

## Experiment 9. Mixture solution.

a) 8 parts KCl + 2 parts  $\text{CaCl}_2$ 

TABLE 18

The shoot was removed at the base of the epicotyle and the stump was covered with wet cotton

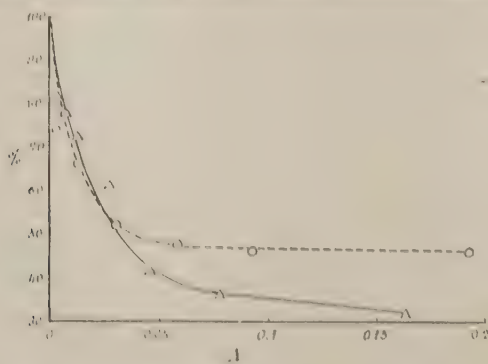
$\Delta$ Water absorption (%)	0.191	0.093	0.058	0.030	0.013	0.007	0.003
1	48.3	49.5	53.7	51.2	71.4	71.7	75.0
2	46.1	43.0	44.1	55.2	63.3	86.2	73.5
Mean value	47.2	46.3	48.9	53.2	67.4	78.9	74.3

b) 2 parts KCl + 8 parts  $\text{CaCl}_2$ 

TABLE 19

The shoot was removed at the base of the epicotyle and the stump was covered with wet cotton

$\Delta$ Water absorption (%)	0.163	0.078	0.045	0.026	0.011	0.007	0.003
1	25.2	37.5	43.5	68.1	75.0	84.2	81.8
2	38.3	35.7	43.5	57.1	69.4	71.0	81.8
Mean value	31.8	36.2	43.5	62.6	72.2	77.6	81.8

Fig. 10. Mixture solution  $\bigcirc$  - - - - - 8 K + 2 Ca  
 $\triangle$  ————  $\triangle$  2 K + 8 Ca

As in Part A, the absorption of water by the root of the decapitated plant from KNOP solution was estimated. The results are shown in Table 20 and Fig. 11.

TABLE 20

The shoot was removed at the base of the epicotyle and the stump was covered with wet cotton

Water absorption (%) $\Delta$	0.215	0.170	0.120	0.060	0.030	0.018	0.003
1	27.0	37.6	28.7	38.5	61.1	65.1	84.8
2	31.9	15.2	37.9	46.2	66.7	75.0	81.9
Mean value	29.5	26.4	33.4	42.3	63.9	70.0	83.4

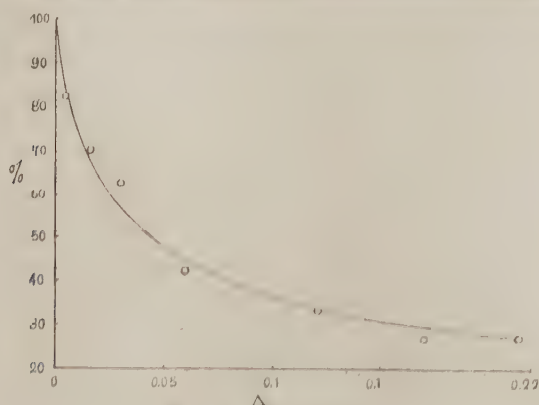


Fig. 11. KNOP solution

In Exp. 6 it is a noteworthy fact that when concentrated sugar solutions were used, a contrary flow of water occurred from root into the surrounding solution. Theoretically there must be a solution of a certain concentration, in which neither absorption nor outflow happens. It is, therefore, not impossible to determine the suction force of the root itself by finding out such a concentration of sugar solution. In the present case a sugar solution of  $\Delta = 0.15$  fulfilled just this condition; the water absorption was stopped for 20 minutes after the transference from water though after 30



minutes a very slight absorption was again recognized. If this secondary insignificant absorption can be neglected, the proper suction force of the root of the decapitated plant may be estimated as 1.9 atm. Applying the formula:

$$A = k(S - R^a),$$

BRIEGER estimated the suction force of the root of the intact plant of *Phaseolus multiflorus* at 2.6 and 3.3 atm. These values are much larger than those determined by the present author.

As seen from Tables 13 and 14 and Fig. 7 the root of the decapitated plant lost much water to the surrounding sugar solution of  $A = 0.20$ , but the root of the intact plant, as shown in Exp. 1, was able to absorb water from the same solution. A similar fact was also found by KRAMER (1932). He removed the tops of sunflower seedlings and attached glass tubes to the cut stems. The exudation of water was indicated by the rise of the water columns in the tubes. When the water surrounding the roots was replaced by a sucrose solution having an osmotic value of one atmosphere, no further exudation of water was recognized. Sunflower seedlings with intact tops remained unwilted in a sucrose solution having an osmotic pressure of two atmospheres even when they were placed under conditions favouring rapid transpiration. KRAMER attributed this difference of the power of water absorption mainly to the suction force of the intact plant, which was developed by transpiration.

In the present work the decapitated plant stopped the absorption of water for 20 minutes after the transference from pure water into a sucrose solution of  $A = 0.150$  (1.94 atm.), while in the case of the intact plant the same stoppage was recognized in a sucrose solution of  $A = 1.22$  (14.68 atm.). The difference of suction force between the intact and the decapitated plant mainly results from an additional action of the shoot of the former. This relation may be expressed by the following formulae:

$$S_i = S_d + T \quad \text{or} \quad T = S_i - S_d$$

where  $S_i$  is the suction force of the intact plant,  $S_d$  the suction force of the decapitated plant, and  $T$  the suction force of the top of the plant. From these formulae the suction force of the top may be estimated, but this is variable with factors which influence the transpiration etc. The suction force of the top of a seedling of *Phaseolus vulgaris*, determined under the conditions of the present

work, namely at 28°C air temperature, 60% relative humidity and 21°C solution temperature, is

$$T = 14.68 - 1.94 = 12.7 \text{ atm.}$$

This value is rather large, and the influence of the top of a plant on the absorption of water through the root must be regarded as of great importance. KÖHNLEIN (1930) tried to determine the suction force of the shoot of *Zea Mays*, which is exerted on the root. However, the estimated value 13.7 atm. under the transpiration of 7 mg. per minute was regarded by him as improbably too high. RENNER (1929) also found such high value. According to KRAMER (1932, 1933) the rôle of the root for the water absorption is only as absorbing surface. Whether, as estimated by KRAMER, no important rôle would be attributed to the root for the mechanism of the water absorption by plant body needs to be determined by further investigations. Such contrary flow of water from the root of the decapitated plant to the surrounding solution was not recognized in solution of electrolytes either in single solution, or in salt mixture. This may be explained as due to the easier penetration of electrolytes than sucrose through protoplasm.

The water absorption of the decapitated plant from concentrated solution of KCl exceeded that from the single solution of  $\text{CaCl}_2$ , but in diluted solution the relation became the contrary. In mixture, however, the water absorption from the solution (8 parts KCl + 2 parts  $\text{CaCl}_2$ ) exceeded always that from the mixture (2 parts KCl + 8 parts  $\text{CaCl}_2$ ) and the difference of absorbed amount of water increased with the increase of concentration of solution and this result is similar to that with intact plants (Exp. 4 in Part A). The form of the curve of water absorption by the root of decapitated plant from KNOP solution, as shown in Exp. 10 (Fig. 11), is greatly different from that secured with the intact plant in Exp. 5 in Part A. In the latter case a straight line resulted, while in the former a curve was traced. This difference seems to come from the degree of suction force developed by transpiration and ascent of sap. Water absorbed by intact plants from KNOP solution can be transferred to the shoots swiftly without any retardation by the transpiration stream. From the comparison of graphs we may say, therefore, that in the water absorption by the intact plant from KNOP solution the suction force of the shoot can be much greater than it is from any single salt or sugar solution.

## Summary

1. The quantitative relation between the amount of water absorbed by the root of a seedling of *Phaseolus vulgaris* and the concentration of the surrounding solution, and the influence of the nature of salts on the water absorption were carefully studied under constant external conditions.

2. The transference reaction (Ueberführungsreaktion), which takes place when water or solution surrounding the root is replaced by another solution having a higher osmotic value, varies according to the concentration and kind of solution.

3. The relation between the water absorption and the concentration of solution shows a curved graph, but not a straight line, except in the case of water absorption by the intact plant from KNOP solution. Even in the case of the latter solution, the relation expressed by a straight line was no longer recognized, if the top of the plant was removed; a curved graph resulted and the total amount of water absorbed from the same solution was much reduced. It is probable that suction force of the top of a plant which is developed by transpiration plays some rôle in this relation.

4. The accelerating action of K-ion and retarding action of Ca-ion on the absorption of water by plant root were remarkable in mixtures (8 parts KCl+2 parts  $\text{CaCl}_2$  or 2 parts KCl+8 parts  $\text{CaCl}_2$ ) than in their single solutions.

5. The suction force of the top of a *Phaseolus vulgaris* seedlings, under a certain constant external conditions, namely at 28°C air temperature, 60% relative humidity of air and 21°C solution temperature was estimated as 12.7 atm., while the suction force of the root under the same condition as 1.9 atm. The very important rôle of the suction force of the transpiring shoot must be taken into consideration for the explanation of the mechanism of the water absorption by the plant root, while also the suction force of the root itself is not to be ignored.

The writer wishes to express his sincere gratitude and hearty thanks to Prof. T. SAKAMURA for his suggestion and guidance throughout the present work.

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# Metaxenia in the Japanese persimmon

## Shape and sweetness

By Yakichi NOGUCHI

Institute of Plant Breeding, Tokyo Imperial  
University, Tokyo, Japan

With 2 text-figures

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A great many varieties of Japanese persimmons are cultivated in Japan, which have different morphological and physiological characters, such as form of the tree, shape of the fruit, ripening period, and so on. In general many people believe that Japanese persimmons are monoecious plants. Most of them, however, bear only pistillate flowers and a few varieties are found which have both pistillate and staminate flowers on the same tree. Quite recently NAMIKAWA (1932) has made clear the above facts after histological and cytological investigation of the development of the sexual organs: he has examined twenty-seven varieties and found only four with perfect flowers. From these sexual conditions it is obvious that most pistillate flowers of the Japanese persimmon are fertilized with pollen of other varieties for setting fruits<sup>(1)</sup>.

Some years ago SWINGLE (1928) and NIXON (1928) found that pollen from different varieties of the date-palm had different effects on the size and ripening period of the fruit produced. As the cause of that phenomenon it was suggested that the embryo or endosperm of the date seed, or both together, secreted a substance like hormones, which affects the whole development of the date fruit, including tissues belonging morphologically to the mother plant. He also proposed the term "metaxenia" for the effect of pollen upon maternal tissue. HARRISON (1931) has reported a similar phenomenon in bolling period, lint length, and seed fuzziness in cotton.

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(1) Sometimes the Japanese persimmon sets fruit parthenocarpically, but this is not considered in the present paper.

NEBEL (1930, 1932) and KRUMBHOLZ (1933) discovered metaxenia in some characters of the apple; and YASUDA (1930) also found it in *Solanum* crosses. Even SCHAFFNER (1928) supposed that metaxenia is only physiological in origin and may be called ectogamy.

As mentioned above, the sexual and fertilizing relation of the Japanese persimmon is peculiar, and each variety differs from every other in the size, weight, and ripening period of the fruit. In addition to these differences the fruit is divided into two groups, one of which becomes very sweet when it ripens, but in the other the ripening fruit remains astringent and needs to be ripened artificially in order to be edible.

Even though the study of metaxenia is difficult, it is sufficiently interesting from both scientific and practical standpoints to warrant investigation. So I have studied this phenomenon for the past two years and discovered some results which will be described in this paper.

### Materials and methods

For cross-pollination experiments it is very advantageous to have the female and male flowers, or at least female flowers, situated in different trees, because there is no need of castration. The flowers were covered with paper bags before they opened, and the

TABLE 1  
The dropping of the fruits after fertilization.

Varieties	No. of flowers crossed	No. of fruits dropped	Percentage of dropping
Zenjamaru	66	23	34.8
Hanagosho	79	36	45.6
Egosho	68	54	79.4
Seihakuji	153	49	32.0
Saijo	60	12	20.0
Fuji	60	27	45.0

female flowers were pollinated when the stigmas were receptive. In order to make reciprocal crosses so as to confirm the results specifically, it was possible to find in 1930 only four varieties, viz.,

"Zenjimarū," "Egosho," "Hanagosho" and "Seihakuiji." Three of these varieties bear sweet fruits, but the last one has astringent ones. In 1931 two more varieties were used, "Saijo" and "Fuji"; and both have only female flowers and astringent fruits.

One of the most baffling things in this experiment was the dropping of the fruits after fertilization. A record of such an instance is given in Table 1.

The heavy dropping, as stated above, interfered so much with the experiment that the result was quite unsatisfactory. At the end of May bags were put over the flowers, and they were crossed at their blooming period in June. Very often in order to avoid mistakes in testing the fruits for sweetness or bitterness my students were invited to assist during the experiments.

### Results of experiments

As SWINGLE and NIXON first reported the phenomenon of metaxenia as affecting fruit size in the date-palm, the same sort of results were expected in the Japanese persimmon. For this purpose the length and diameter of all the cross- and self-pollinated fruits were measured but no marked differences were found. To avoid confusion, only one instance will be reported. The two varieties had the most remarkable difference in the size of their fruit. Self-pollinated fruits of the variety "Zenjimarū" were very small, the length being only  $4.44 \pm 0.05^{(1)}$  cm (14)<sup>(2)</sup> and the diameter,  $5.83 \pm 0.05$  cm; but in the variety "Seihakuiji" the fruits were comparatively large, the length being  $6.07 \pm 0.08$  cm (11) and the diameter  $7.22 \pm 0.15$  cm.

Both the differences in length and diameter are very marked, being  $1.63 \pm 0.09$  cm and  $1.39 \pm 0.15$  cm respectively. The average length and diameter of the fruit, which grew after cross-pollination between these two varieties are as follows: the fruit of "Zenjimarū" with "Seihakuiji" pollen is  $4.48 \pm 0.03$  cm (23) in length and  $5.74 \pm 0.05$  cm in diameter; and the fruit of the reciprocal crossing is  $5.84 \pm 0.05$  cm (33) in length and  $7.48 \pm 0.05$  cm in diameter. No special difference could be found. The two kinds of pollen from the

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(1) Probable error.

(2) The number within parentheses denotes the number of fruits which were measured.

above mentioned two varieties fertilized flowers on the same tree of the varieties "Saijo" and "Fuji," and the ripened fruits were measured. But the same results were obtained, as Table 2 will show, in which only the average values are given, because the evidence is quite clear.

TABLE 2  
The fruit size with the different kinds of pollen.

Pollen used	Saijo			Fuji		
	No. of fruits examined	Length	Diam.	No. of fruits examined	Length	Diam.
Zenjimarui	23	7.37	5.71	10	6.83	7.78
Seihakui	21	7.23	5.71	23	6.66	7.51

It was disappointing not to find the metaxenia-like phenomenon in the fruit size of the Japanese persimmon, but when making the measurements some definite changes in the form of the fruits were noted as due to the different kinds of pollen. For instance, the round fruit became somewhat pointed in the ripening stage when it had been pollinated with pollen of the pointed fruit variety. Thus the main point in the investigation was changed from the size of the fruits to their form. Before giving precisely the data of measurements concerning form of the fruits descriptions of the typical fruit form of the varieties which were used are necessary. The fruits of (1) "Zenjimarui" are almost globose; (2) "Egosho" and (3) "Hanagosho" are oblong with a somewhat pointed apex; and (4) "Seihakui" is also oblong but rather long with a pointed apex.

As it is very difficult to compare the form of the fruits of varying sizes the most convenient and accurate method must be taken for comparison. After careful consideration the height of the fruit was chosen as a unit and compared with the proportional values of the diameters at the height of one third from the base and one third from the apex. The relative lengths of these two diameters to the height show numerically by this method the form of fruits whether the top and base are narrow or not. It is convenient to take 100 as a unit for measuring all the heights of fruits. In this way one can get proper proportions of the diameters. Table 3 gives the real and relative average values of self- and cross-fertilized fruits.

At a glance, it is clear that the fruits of "Seihakuji" are very pointed. Carefully observing the last column of the table we can easily draw the definite conclusion that the fruit pollinated with the pollen from the variety with pointed fruit becomes somewhat narrower even if the difference is very small. When the probable errors

TABLE 3  
The influence of pollen upon the fruit shape.

Pollination	No. of fruits measured	Real measurement (Average in cm)			Relative number, with the height 100 as the base		
		Height	Diameter 1	Diameter 2	Height	Diameter 1	Diameter 2
Z (s)	14	4.41	5.79	5.34	100	131	121
Z×S	23	4.48	5.74	5.19	100	128	116
S×Z	33	5.84	7.48	6.26	100	128	107
S (s)	11	6.07	7.22	6.33	100	119	104
E (s)	4	4.75	6.93	6.03	100	146	127
E×S	10	5.46	7.29	6.35	100	135	116
S×E	28	5.51	7.65	6.82	100	139	124
S (s)*	11	6.07	7.22	6.33	100	119	104
H (s)	10	4.73	7.14	6.16	100	151	130
H×S	30	4.89	7.14	6.24	100	146	128
S×H	21	6.01	7.73	6.35	100	129	106
S (s)	11	6.07	7.22	6.33	100	119	104

Z = "Zenjimaruru", E = "Egoshō", H = "Hanagosho", S = "Seihakuji";  
(s) = self-pollinated, × = cross-pollinated.

Diameter 1 is at the height of one-third from the base and Diameter 2 from the top.

\* The numbers are repeated for the sake of convenience for comparison.

of the differences were calculated they were often insignificant; but it should be convincing that these changes in form are examples of metaxenia, because the influence of the pollen upon the maternal tissue is not considered so strong; and if the difference is especially significant, the phenomenon of metaxenia would have been easily found in the past. In 1931 the two cases, "Saijo" and "Fuji" pollinated with different kinds of pollen were examined, but no such difference could be found; so the numerical data are omitted in this paper.



Another example of metaxenia in the Japanese persimmon was discovered in my later experiments. As mentioned above, the Japanese persimmon is divided into two distinct groups from the point of sweetness of the fruit, although the degree of sweetness is somewhat variable in the sweet varieties. "Zenjimaru," "Egoshō" and "Hanagoshō" are the typical sweet varieties, and "Seihakuji" is, on the contrary, the completely astringent variety. Self- and cross-pollinations were made with these four varieties. Table 4 makes clear the effects of cross-pollination on the taste of the fruit. The symbols indicating degrees of sweetness and astringency are explained below the table.

TABLE 4

The influence of pollen upon the sweetness of fruit.

Varieties and crosses	Degree of sweetness					
	+S	S	-S	SA	sA	A
Z (s)	11	1	2			
E (s)		4				
H (s)		10				
Z × S	2	10	5	6		
E × S		6	2	2		
H × S		12	17	1		
S × Z						33
S × E				1	4	25
S × H					9	18
S (s)						11

The numbers denote the number of fruits which were examined. Z = "Zenjimaru", E = "Egoshō", H = "Hanagoshō", S = "Seihakuji", (s) = self-pollination, × = cross-pollination, +S = very sweet, S = sweet, -S = slightly sweet, SA = part of the fruit sweet, sA = flecked with sweetness, A = astringent.

It can be said without doubt that the taste, especially the sweetness, is changed by the pollen from an astringent variety and it is interesting to note that the change in the fruit is strong near the seeds.

In addition to the above results, in 1930 the flowers of "Mizugaki" (a completely astringent variety) pollinated with the pollen

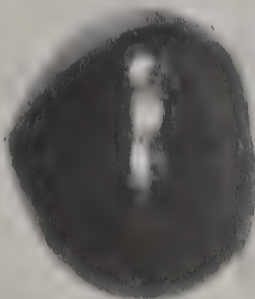
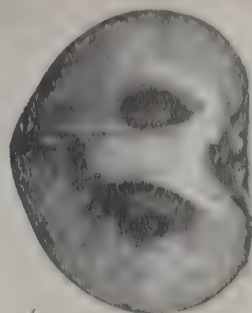


Table 1. Shape and sweetness of persimmon fruits. The fruits were classified into three groups according to their shape: (1) round, (2) oval, and (3) pear-shaped. The sweetness was measured by the percentage of soluble solids (SS) in the fruit flesh. The data are presented as the mean ± standard deviation (n = 10).

Group	Shape	SS (%)
1	Round	18.5 ± 1.2
2	Oval	19.2 ± 1.5
3	Pear-shaped	20.1 ± 1.8

Table 2. Shape and sweetness of persimmon fruits. The fruits were classified into three groups according to their shape: (1) round, (2) oval, and (3) pear-shaped. The sweetness was measured by the percentage of soluble solids (SS) in the fruit flesh. The data are presented as the mean ± standard deviation (n = 10).

Group	Shape	SS (%)
1	Round	18.5 ± 1.2
2	Oval	19.2 ± 1.5
3	Pear-shaped	20.1 ± 1.8

of sweet variety "Zenjimarū" produced some fruits in which black spots containing tannin could be found around the seeds. More exact tests for astringency were made by staining the tannin of the fruit with a four per cent solution of ferric oxide applied on the section faces when the tannin changed its color to bluish black as the result of a chemical change. Results of such an examination are shown in Fig. 2.

From all these results it may be concluded that the Japanese persimmon sometimes shows metaxenia in the degree of sweetness of the fruits, and that the flesh near the seeds exhibits a more marked change in taste.

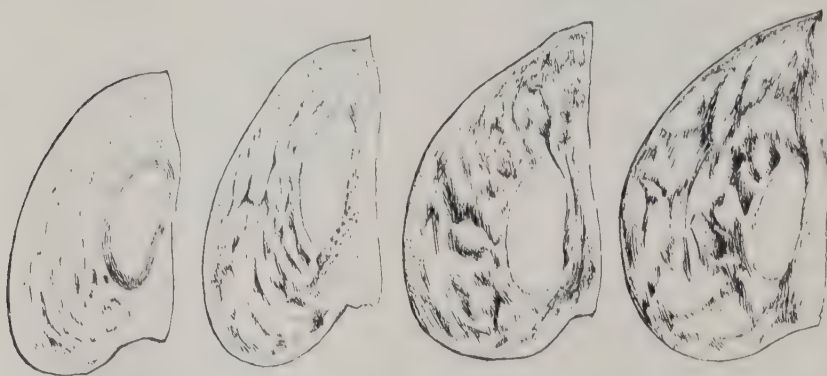


Fig. 2. The influence of pollen upon the sweetness of fruits. The section faces of fruits stained with a four per cent ferric oxide solution. Left to right: Self-pollinated "Zenjimarū" (sweet), "Zenjimarū" pollinated with "Seihakkuji" (astringent) pollen, "Seihakkuji" pollinated with "Hanafusho" (sweet) pollen and self pollinated "Seihakkuji".

### Discussion and summary

Some peculiar phenomena were found in the Japanese persimmon, in which the effect of foreign pollen changed the form and the pulp sweetness of ripening fruit, and these are, no doubt, examples of metaxenia in SWINGLE's meaning. The experimental data in this case are not complete enough to be treated exactly by biometrical methods, because the influence of the pollen is not such as to be easily recognised. In Japan it is thought that the fruits of the

Japanese persimmon differ in their form, especially in length, according to the number of seeds which develop in the fruit. In order to avoid an error in studying such a physiological phenomenon as metaxenia, I calculated the correlation coefficients between length of fruit and number of seeds as found in my data with the following results (Table 5). They denote, however, sometimes positive and sometimes negative correlation, and are therefore not very significant.

TABLE 5

The correlation coefficients between height of fruit  
and number of seeds.

Pollen used	Fruits			
	Z	E	H	S
Z	—	—	—	+0.2088
E	—	-0.1465	—	-0.1171
H	—	—	+0.2679	-0.1100
S	+0.3643	-0.1605	+0.1508	-0.1465

Z = "Zenjimaruru", E = "Egoshō", H = "Hanagoshō", S = "Seihakujū"

The simplest and most probable theory for the explanation of metaxenia in the date-palm was given by SWINGLE who proposed that the embryo or endosperm or both of them secrete one or more soluble substances (analogous to the hormones secreted by the ductless glands of animals), which diffuse into the tissues of the mother plant and produce an influence on their development. YASUDA found some metaxenia-like phenomena in the color of the outer part of the seeds, when the flowers of *Solanum citrifolium* were pollinated with *S. Delilei* and *S. aggregatum* pollen. He observed the paternal color, especially around the seeds, but changes also appeared even in the case where no development of the seeds could be seen in the center. From this experiment he doubted frankly SWINGLE's explanation, because the undeveloped seeds had no ability to secrete the hormone-like substance. He tried some experiments for finding a suitable explanation, but in vain. Though it cannot be decided from my experimental results exactly, whether SWINGLE's explana-

tion is suitable or not, some cases were observed in which the pulp of the fruit was changed in sweetness by the foreign pollen, especially around the complete seeds. So at least as far as the results of my experiment are concerned, his explanation can be accepted as the probable one.

Quite recently NEMEL discussed metaxenia in the apple from the practical point of view of his experimental results. He examined several characters of fruits, which are most important in practical use, i.e., size, acidity and total sugar; and he also found that the appearance of all the fruits of McIntosh with Red Astrachan pollen are in general better than that with Yellow Bellflower pollen. At the beginning of my experiments with the Japanese persimmon, I thought also that some very important questions in fruit production would arise, if I could find the phenomenon of metaxenia, because most varieties of Japanese persimmon have only female flowers. As evidence of metaxenia in the shape and sweetness of the fruits has already been found it is hoped that, after more complete experimentation, certain practical applications will be available.

These experiments have been done in the orchards of the Agricultural Experiment Station of Kanagawa Province at Ninomiya, Kanagawa, and I wish to express my heartfelt gratitude to the director of the orchard, Dr. K. FUJIKAWA for the use of materials; and to Prof. E. S. BARCOCK, of the University of California, where I prepared this paper, for his kind help in its publication.



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# Cyto-genetical studies on *Oryza sativa* L.<sup>(1)</sup>

By Toshitaro MORINAGA

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Through the efforts of many breeders and genetists, a large number of genetical studies on *Oryza sativa* were published during the last three decades. The results of those studies have been well surveyed in the two monographs compiled by IKENO (7) and MATSUURA (14). On the other hand general karyological studies on the species were carried out by KUWADA (12), and extensive observations on the chromosome number of numerous varieties or mutant types were made by NAKATOMI (24) as well as by the author and his coworker (15). SELIM (28) studied especially the nucleolus of the species. In the field of cyto-genetics, interesting investigations were made by ISHIKAWA (8), and KATO and others (9). The former studied some sterile mutants and the latter some sterile combinations of the varieties. NAGAI (19), AKEMINE (1) and RAU (27) also made cytological observations on the species to some extent.

All the varieties or mutant types hitherto investigated possessed 12 chromosomes in reduced number, and no varieties or varietal hybrids ever examined showed any irregular meiotic process. Thus *Oryza sativa* seemed, after all of its remote age and wide area of cultivation, to be a species composed of a single karyological type. Such apparent stability of the number of chromosomes, together with the difficulty of securing the wild relatives of the species, at one time indicated that the cyto-genetical studies on *Oryza sativa* was a task of very limited prospect.

In 1931 the author and his coworker (16) found the first chromosomal mutant, viz. a haploid individual. That year apparently marked a turning-point in the cyto-genetical studies of rice. The haploid plants have been found by the author year after year since, and they have also been found by NAKAMURA (23) and RAMIAH and others (26). In the course of these events NAKAMORI (20, 21) found and made

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(1) Contributions from the Institute of Agronomy, Kyushu Imperial University, No. 54.

known triploid and tetraploid plants of the species. In 1932 the author also found a triploid plant, and more than 150 triploid plants and a tetraploid one were found by him in the next year. Indeed the chromosomal mutants, such as haploid, triploid and tetraploid ones are not of so rare occurrence as once believed by the workers on that species. These findings not only gave the author a clue for pursuing the cytogenetical nature of the species, but also encouraged him much to reinvestigate various other problems from the cyto-genetical point of view. The results of investigations thus undertaken will be reported in this series.

# I. Studies on the haploid plant of *Oryza sativa*

By Toshitaro MORINAGA and Eiji FUKUSHIMA

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With 75 text-figures

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The first haploid sporophyte, that is the one having only the gametic number of chromosomes, was found in *Datura*, and now the haploid sporophytes are known in 10 additional genera, namely, *Nicotiana*, *Triticum*, *Crepis*, *Matthiola*, *Solanum*, *Oenothera*, *Pharbitis* (30), *Oryza* (16), *Portulaca* (25), and *Brassica* (18). The mere discovery of haploid individuals, thus, no longer excites the curiosity of the former days, yet the importance of the study on haploid is to be esteemed none the less for that reason. A new finding of haploids in a certain species always offers the genetist a chance to re-inquire into the genomic constitution of that species in a different light. Moreover, several fundamental points about the haploidy itself are the problems of future studies. Among other problems, the authors are specially interested in the following two: a) whether or not the haploid mutation occurs less frequently in true diploid species than in polyploid ones, b) whether the haploid plant shows any disadvantage in carrying out its normal vital functions. The main object of the present paper, however, is the descriptions in detail of what the authors have observed on the haploid plant of rice, and not the discussion of any general problems in the light of the knowledge at present available.

## Seven haploid plants discovered

*Haploid I.* This haploid plant was found in 1931 among the  $F_1$  plants of a varietal hybrid, Dekiyama ♀ × Bunketutô ♂. Dekiyama is a variety of normal type, while Bunketutô is a peculiar one, producing short slender culms very profusely. Thirteen well developed  $F_1$  seeds produced the same number of  $F_1$  plants, of which 12 were proved as true hybrids by their morphological characters, while the remaining one, which was markedly smaller, was proved as a haploid. Some characters of the parental varieties, true hybrid, and the haploid plant are compared in Table 1.



*Haploid II.* This haploid plant was found in 1932 in a  $F_3$  line of a cross, Omati ♀ × Sangokuiti ♂. Omati is one of the most common and profitable varieties, and Sangokuiti is a rare, giant variety of coarse appearance. The height of the diploid individuals composing that  $F_3$  line ranged from 85 cm to 125 cm, the mode being 110 cm. The haploid individual was only 82.7 cm in height and produced 7 culms. The length of ear of the diploid individuals ranged from 16 cm to 24 cm, the number of variants for 21 cm being the largest. The length of the ear of the haploid plant was estimated as 17.8 cm, and its density as 10.2. The spikelet of the haploid was on the average only 0.5 cm long and 0.28 cm in width.

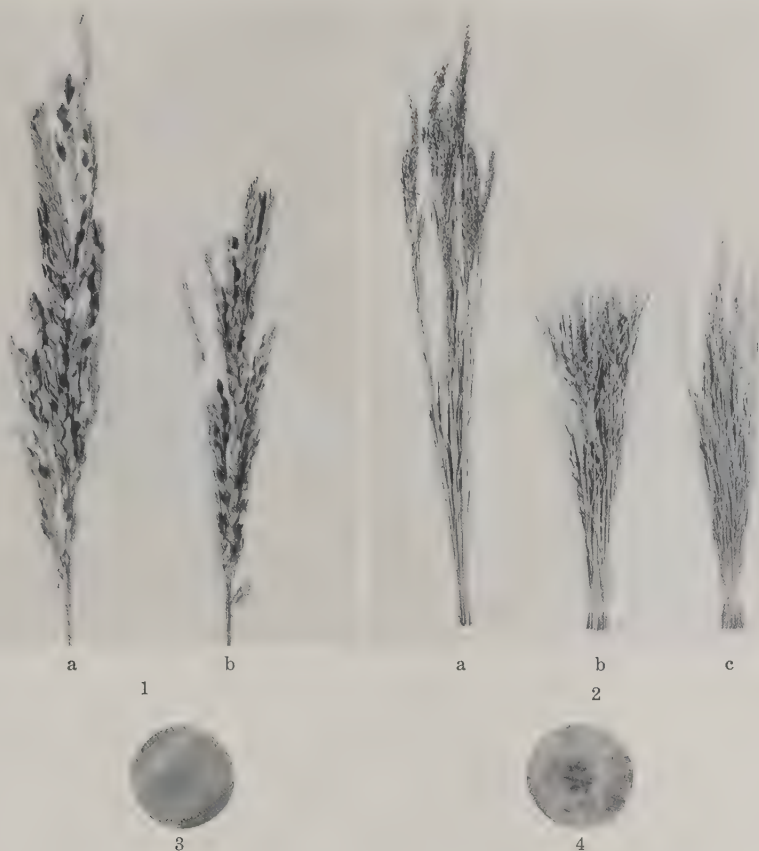
TABLE 1. Comparison of the parental varieties, true hybrid and the haploid plant.

	Dekiyama	Bunketutô	$F_1$	Haploid
Average number of tillers	18.9	88.0	21.1	25
Date of shooting	31/VIII—2/IX	1/IX—4/IX	29/VIII—1/IX	—
Average length of culms (cm)	84	45	84	42
Average length of ears (cm)	20	10	22	15
Average density of ears*	9.3	1.8	7.5	17.2
Average weight of unhulled grains (mg)	22	22	26	11.9
Average length of spikelets (cm)	0.71	0.87	0.74	0.53
Average width of spikelets (cm)	0.35	0.34	0.35	0.28
Awn	without	with	with	without
Colour of the tip of glume	redish purple	white	redish purple	redish purple

\* Number of spikelets ÷ length of ear.

*Haploid III.* This haploid plant was also found in 1932 in a  $F_3$  line of a cross, Kinenmoti ♀ × Taisimotikawari ♂. The maternal variety is a common glutinous one, while the paternal one is a dwarf, *chlorina* variety of tender appearance. The haploid individual was only 68 cm high, and produced 17 ears of which the average length and density were 12.2 cm and 8.2 respectively. The spikelet of the haploid was on the average 0.56 cm long and 0.29 cm wide.

*Haploid IV.* This haploid was found in 1932 in a  $F_2$  line of a cross, Mino ♀ × Sinrikikawari ♂. Here also the maternal variety is one of ordinary type, while Sinrikikawari is an exceptionally dumpy



Figs. 1-4. Diploid and haploid plants of *Oryza sativa*. 1-a, The ear of Dekiyama. 1-b, the ear of Dekiyama haploid (Haploid I). 2-a, Dekiyama, whole plant after harvest. 2-b, the haploid of Dekiyama (Haploid I), whole plant after harvest. 2-c, Bunketutô, whole plant after harvest. 3. Microphotograph of 24 chromosomes in the root-tip cell of diploid. 4. Microphotograph of 12 chromosomes in the root-tip cell of haploid (3 and 4  $\times 1100$ .)

Fig. 1 and 2 show Dekiyama, Bunketutô and the haploid plant after harvest. The haploid plant, though smaller in point of the size of every part, closely resembles the maternal parent. It, no doubt, contains the Dekiyama-set of chromosomes.

variety with dense ears. The individuals in that  $F_2$  line segregated clearly into the parental types. Their height ranged from 50 cm to 110 cm, and the frequency distribution curve for height showed the first maximum population at 95 cm and the second one at 65 cm. A similar bimodal curve was also obtained for the length of ear, showing the maximum populations at 18 cm and 11 cm. The haploid plant was 54.9 cm high and produced 14 ears, of which average length and density were respectively 10.3 cm and 7.3. The length of the haploid spikelet was on the average 0.52 cm and the width 0.25 cm.

*Haploid V.* This haploid plant was found in 1933 in a  $F_4$  line of a cross, Omati ♀ × Kōketumoti ♂. Both parental varieties are of normal type about 120 cm high. The  $F_1$  plant of this mating was highly sterile.<sup>(1)</sup> The haploid plant was only 65 cm high, and produced 6 culms, while the average height of the diploid plants in the same line was 120.4 cm. The length of the haploid ear was on the average 11.9 cm, contrasting with the corresponding value of 22.6 cm for the diploid sister individuals. The average length and width of the haploid spikelets were respectively 0.53 cm and 0.27 cm, while those values for Omati were 0.75 cm, and 0.37 cm, and 0.92 cm and 0.32 cm for Kōketumoti. The density of haploid ear was only 3.3. The haploid plant bore a resemblance in some respects to Omati, and in others to Kōketumoti.

*Haploid VI.* This haploid plant was found in 1933 in a field of Omati under common cultivation. The haploid plant was 82.8 cm high and produced 14 culms. The average length of ears was 14 cm. The length and width of the haploid spikelet averaged 0.55 cm and 0.28 cm respectively.

*Haploid VII.* This haploid plant was also found in 1933 in a field of Okusirasasa under common cultivation. It was 54.5 cm high and produced 7 culms, the average length of ears was 10.6 cm. The height of Okusirasasa is about 100 cm. It produces ears about 19 cm long. The length and width of the haploid spikelet were on the average 0.51 cm and 0.25 cm respectively, while the corresponding values for the diploid spikelet were 0.66 cm and 0.34 cm.

As described above, haploid plants of *Oryza sativa* have been discovered every year since 1931. In the first two years they were found only in the progenies of varietal hybrids, but in the third year

(1) Kōketumoti belongs to *indica*-type of KATO and others. All other varieties referred in this paper belong to *japonica*-type. The hybrids between the types are always highly sterile.

they were also found in certain common varieties under ordinary cultivation. Hybridization is not the essential factor for causing haploid parthenogenesis. Thus the haploid plant would be found with equal frequency in the farmer's field as in the hybrid progenies, if sought for with sufficient diligence.

All the haploid plants of rice were markedly dwarf, and produced short ears with small spikelets. The leaves were also smaller as compared with the leaves of the diploid relatives. The tillering capacity and the density of ear were of no use as an indication of haploidy.

### Sterility and the size of caryopsis

All the haploid plants are characterized by sterility as well as diminution of the size. The original plants of Haploid I and Haploid VI produced only one seed each, while Haploid II-V and Haploid VII produced no seeds in the first year. Haploid I was propagated vegetatively to 33 individuals in 1932, but they produced no seeds without artificial pollination. Those plants were again multiplied, and 1212 individuals were grown in 1933 in a common rice field. About 50 individuals were later transplanted to pots for artificial hybridization. The rest of the individuals in the field produced in total 13800 ears of which 37 ears produced one or two seeds. The total number of the spikelets of these 37 ears was 5004, and the total number of seed obtained was 41. The average fertility for those 37 ears was 0.82%, and the average fertility for the whole 13800 ears was estimated, assuming the average number of spikelets per ear as 135.25, to be 0.0022%. The haploid plant rarely produces diploid tillers or diploid parts of the stem. The seeds produced on such parts are not taken into account in the above calculations. The unhulled grain of Haploid I obtained in 1931 was 0.51 cm long and 0.27 cm in width, weighing 11.6 mg, while the corresponding values for the unhulled grain of Dekiyama were respectively 0.71 cm, 0.35 cm and 26.4 mg. That seed of Haploid I germinated, but the seedling could not survive its plumule stage.

When the haploid plant is cross-pollinated with the pollen-grains of a diploid plant, its fertility increases noticeably. In 1932, 3 seeds were obtained from 282 castrated flowers by artificial pollination with the pollen-grains of diploid varieties. Also 11 seeds were produced by 457 flowers pollinated with normal pollen-grains without previous castration. The percentages of flowers which set the seeds were 1.06% for the

castrated ones and 2.41% for those without castration. The average weight of those cross pollinated seeds was only 9.04 mg (Table 2).

Out of those 14 seeds, 11 plants were obtained. They were normal in appearance and perfectly fertile.

In 1933, taking 50 individuals of Haploid I, 5 individuals of Haploid III, and 1 individual of Haploid IV, 5156 flowers in total were castrated and pollinated artificially with normal pollen-grains. Thirty-four flowers, or 0.66% of the total, produced seeds. The weight of the seeds ranged from 10.1 mg to 7.5 mg.

TABLE 2. The weight of hulled grains produced by Haploid I with the application of diploid pollen-grains

Source of pollen	Weight (mg)	Source of pollen	Weight (mg)
Hap. I × Dekiyama	9.5	Hap. I × Simamurasaki	8.4
„ × „	11.6	„ × „	7.5
„ × „	11.3	„ × Basōmoti	8.3
„ × „	9.4	„ × „	6.1
„ × Rikumaiso	10.3	„ × Okusinriki	8.3
„ × „	—	„ × „	8.5
„ × „	11.0	„ × „	7.3

On pollination, the end of glumes were cut off, for the reason that the grains produced were much deformed.

### Parthenocarpic development of the haploid caryopsis

In 1931 the authors noticed that the spikelet of Haploid I very often contained a thin piece of a crushed ovary wall. Such ovary wall may or may not grow up to the full length of the cavity of the glumes. Three ears taken at random from the original Haploid I had in total 295 spikelets of which 167 contained such parthenocarpic caryopses, while the rests produced neither normal nor parthenocarpic ones. Though the percentages of the parthenocarpic caryopses vary according to plants or environmental conditions, the following table may serve to show its universal and high tendency of occurrence in the haploid rice plant (Table 3).



### Growth habit and somatic chromosomal mutation

To compare exactly the growth habit of haploid and diploid plants, 2 small tillers with 3 leaves were taken on December 17th, respectively from Dekiyama and Haploid I. Each tiller was planted in a pot, and the later development was compared with the following results (Table 4).

TABLE 3. Percentages of the parthenocarpic caryopses of the haploid individuals.

	Number of ears examined	Spikelets with seeds	Parthenocarpic caryopses	Spikelets perfectly sterile	% of parthenocarpic spikelets
Haploid I	10	0	857	162	84.0
„ II	5	0	6	903	0.7
„ III	5	0	188	357	34.5
„ IV	5	0	248	142	63.6
„ V	4	0	136	24	85.0
„ VI	4	0	120	402	22.9
„ VII	4	0	158	404	28.1

TABLE 4. Comparison of the development of normal and haploid plants (average of two plants).

Date of measurement	Haploid I		Diploid	
	Height (cm)*	Number of tillers	Height (cm)*	Number of tillers
15/II	22.8	1.0	29.3	1.0
25/II	22.8	1.0	29.3	1.0
5/III	22.8	1.0	29.3	2.0
15/III	22.8	1.5	29.3	3.5
25/III	22.8	3.5	31.6	4.5
25/IV	42.1	8.0	59.4	13.0
15/V	50.0	14.0	64.5	14.0
25/V	60.9	15.5	68.1	14.0
5/VI	75.5	19.0	98.6	14.5
15/VI	78.5	19.0	102.0	14.5
25/VI	78.5	19.0	102.0	13.0
5/VII	78.8	19.0	102.0	13.0
15/VII	77.8	21.5	103.0	13.0
25/VII	77.8	24.5	104.5	13.0
5/VIII	77.8	30.5	103.0	14.5
5/X	—	41.0	—	23.5

\* The height from the ground to the tip of the tallest leaf.

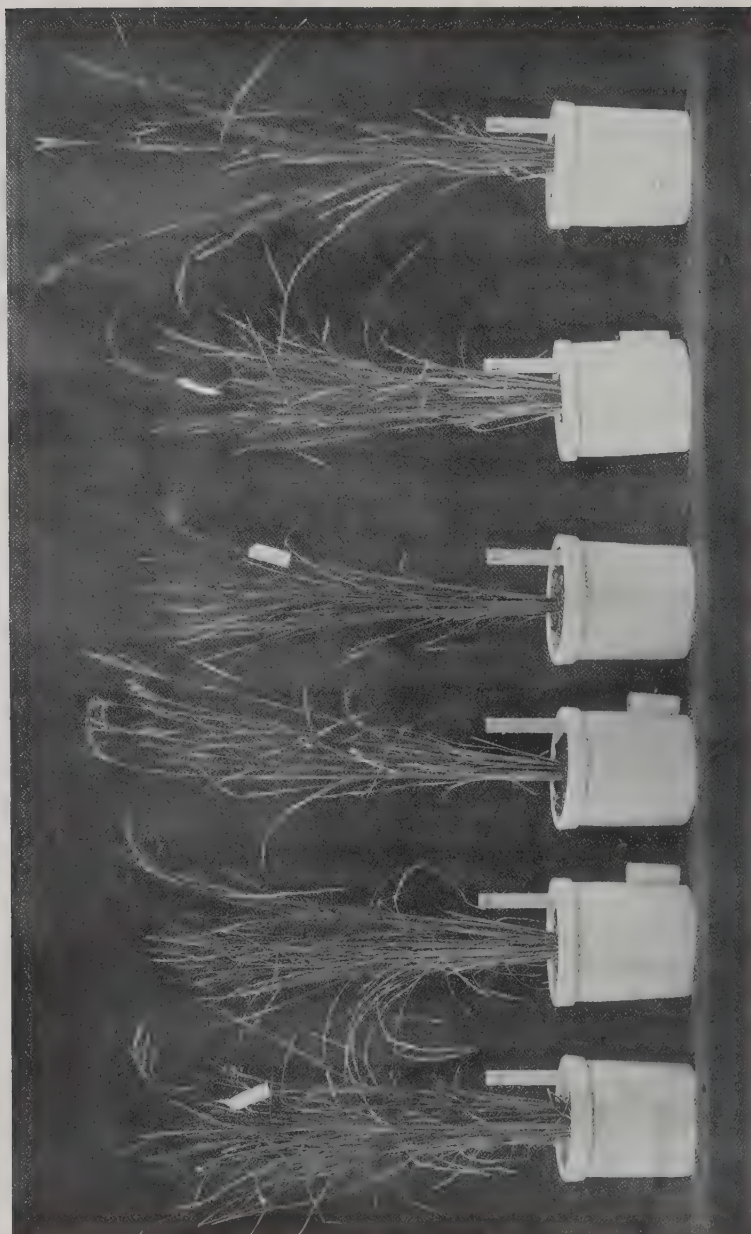


Fig. 5. Whole plant of haploid *Oryza sativa* L. A-D, haploids with haploid and haplo-diploid mosaic ears. E and F, haploids with some diploid tillers.

The diploid plants started growth and tillering earlier than the haploid ones. The height of the haploid plant once approached to that of the diploid in the end of May, but the difference again became greater. Though the haploid plant tillered by slow degrees in the beginning it produced far more stalks in the shooting period than the diploid plant. Both of the haploid plants shot the first ear on the 25th of June, and one diploid shot the first ear on the 30th of June and the other on the 8th of July. The ear of the haploid comes out of the boot tardily, owing to the slow elongation of the uppermost internode of the culm. In the end of August the haploid plants again started tillering very vigorously. When the haploid plants, coming into the ear, are kept in a crossing-house they live longer than those plants kept outside. Such a phenomenon is not noticed for the diploid plants.

Out of 33 individuals of Haploid I in 1932, 2 individuals produced in the next spring several tillers of normal appearance. Such tillers produced ears and spikelets of normal size, and were perfectly fertile. Out of 1212 individuals of Haploid I cultivated in a common field in 1933, two individuals also produced such diploid tillers (Fig. 5 E-F). In the same year 10 individuals were grown respectively from Haploid II, III and IV, and one individual of Haploid IV produced diploid tillers. The somatic chromosome doubling also occurred in a later stage of development. Nine individuals out of 1212 individuals of Haploid I in 1933 produced some ears with haploid and normal spikelets (Fig. 5 A-D and 6). The normal spikelets on such ears were perfectly fertile. The weight of the hulled grains produced by those normal spikelets, to which normal pollen-grains were applied artificially, ranged from 12.4-17.6 mgs. The culms with the ear setting both kinds of spikelets were slightly taller than the simple haploid ones, and the uppermost leaves were somewhat larger than those of the haploid.

## Cytological observations

### Materials and methods

To study the somatic chromosomes, root-tips fixed with BENDA's fixative were sectioned by the paraffin method, and stained with iron-alum-haematoxylin. Micro- and megasporogenesis were studied exclusively on Haploid I. The materials were fixed with BOUIN's solution, and the later treatments were essentially the same as those for the root-tip.

### Observations on the somatic cell and chromosomes

Somatic number of chromosomes was counted for all original haploid plants. They possessed 12 small rod-shaped chromosomes instead of 24. Fig. 3 and 4 (p. 77) are the micro-photographs of the



Fig. 6. A highly fertile ear produced by the haploid A in Fig. 5, only one branch of rachis marked  $\times$  sets haploid spikelets.

metaphasic chromosomes in the root-tip cells of Haploid I, and a normal diploid plant. The 11 offspring plants of the haploid already mentioned about possessed 24 somatic chromosomes.

To compare the size of the epidermal cells, pieces of leaves of Dekiyama and Haploid I, previously treated with chloral hydrate and xylol, were observed under a microscope. Fig. 7 shows the difference of their size very clearly.

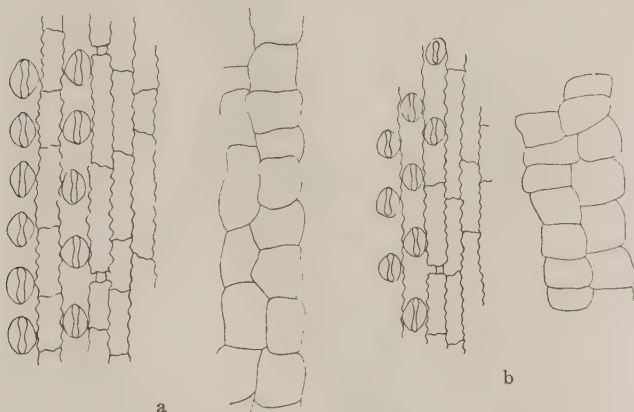
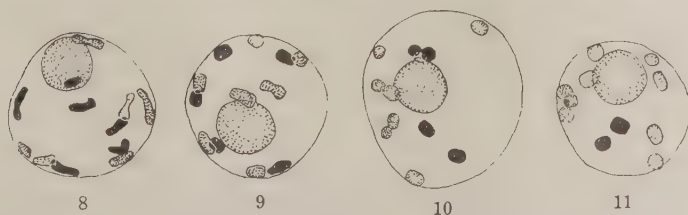


Fig. 7. Epidermal cells. a. diploid, b. haploid.  $\times 570$

### Microsporogenesis

*Heterotypic prophase*: The nucleus in early heterotypic prophase contains a large nucleolus and a small quantity of chromatic threads. Synizesis occurs in haploid as it does in diploid. In the stage corre-

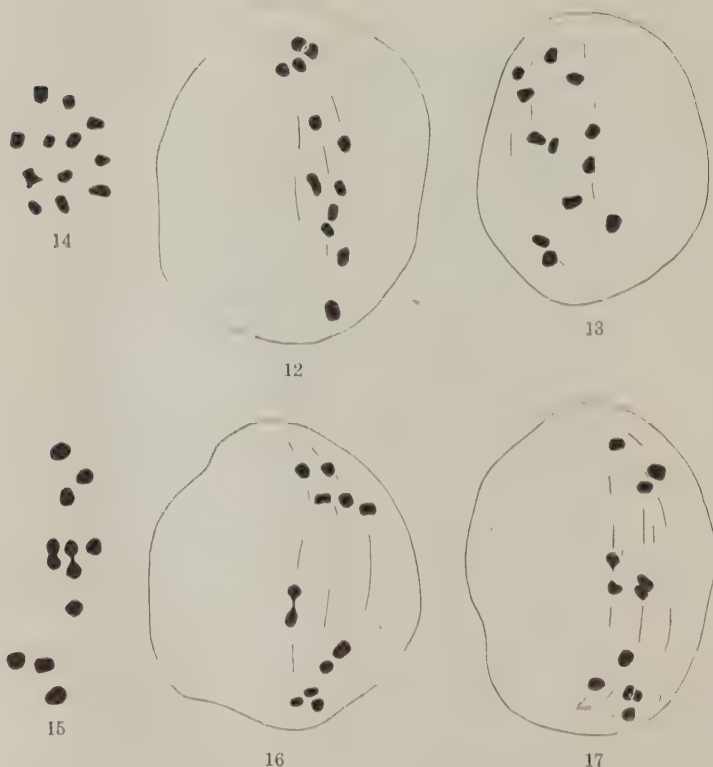


Figs. 8-11. Diakinetive nuclei of haploid *Oryza sativa*. 8. Early stage with rod-shaped univalents. 9. Slightly later stage with spherical univalents. 10. Contact univalents in late diakinesis. 11. Side by side position of univalents in late diakinesis.  $\times 2670$

sponding to early diakinesis, a large nucleolus and 12 rod-shaped univalent chromosomes appear dispersedly near the surface of the nucleus



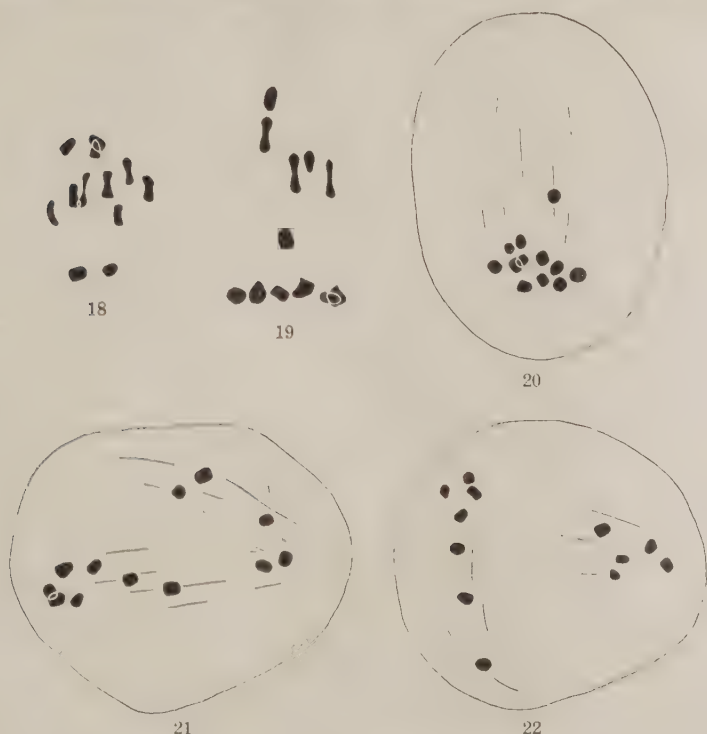
(Fig. 8). The univalents gradually become spherical, and the nucleolus disappears finally. Often, in the diakinetic nucleus, there appear many small chromatic granules, some of which are clearly connecting to



Figs. 12-17. Heterotypic metaphases of haploid and diploid *Oryza sativa*. 12, 13. Heterotypic metaphase of haploid, showing 12 univalents. 14. Heterotypic metaphase of diploid, showing 12 bivalents. 15-17. Heterotypic metaphase of haploid, showing occasional bivalent formation.  $\times 2670$

chromosomes. Such granules are also observable in diploid pollen mother-cells. In a certain nucleus two univalents appeared in contact, or took position side by side (Fig. 10 and 11).

*Heterotypic meta- and anaphase:* In the heterotypic metaphase 12 univalents are scattered on a characteristic narrow spindle appearing across the cell (Fig. 12 and 13). The spindle usually bends in a crescent, and on rare occasions it is strongly forced against the cell membrane. For comparison a polar view of heterotypic metaphase of a diploid plant is presented in Fig. 14. The univalents then travel directly to



Figs. 18-22. Heterotypic meta- or early anaphase of haploid *Oryza sativa*. 18, 19. Imperfect equatorial arrangement of univalents. 20. Exceptional uneven distribution of univalents. 21. Twelve univalents distributed on a branched spindle. 22. Twelve univalents on two independent spindles.  $\times 2670$

either of the poles, perhaps to the nearer one, without making a true equatorial plate arrangement. It makes the distinction of the meta- and early anaphase very unreliable. The authors observed in total 135

microsporocytes in such meta- or early anaphase, of which 98 sporocytes showed distinctly 12 univalent chromosomes. In the rest 37 microsporocytes, however, two, or rarely four, univalents appeared in



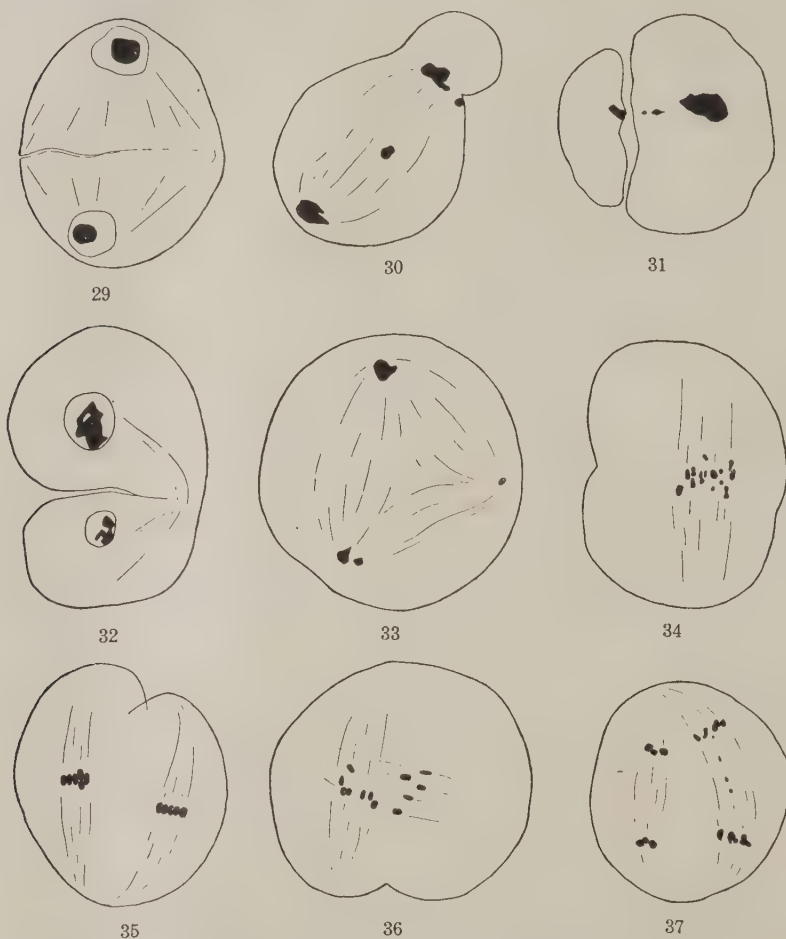
Figs. 23-28. Heterotypic anaphase of haploid *Oryza sativa*. 23. Most commonly 6-6 distribution of univalents. 24, 27. Different appearances of chromosomes in corresponding stage of division; 5-1-6 distribution. 25, 26. Splitting of univalents in various degrees. 28. Appearance of chromosomes in a still later stage.  $\times 2670$

contact making one or two loose pairs. Such contact chromosomes were observed near the poles as well as near the equator. Most of the

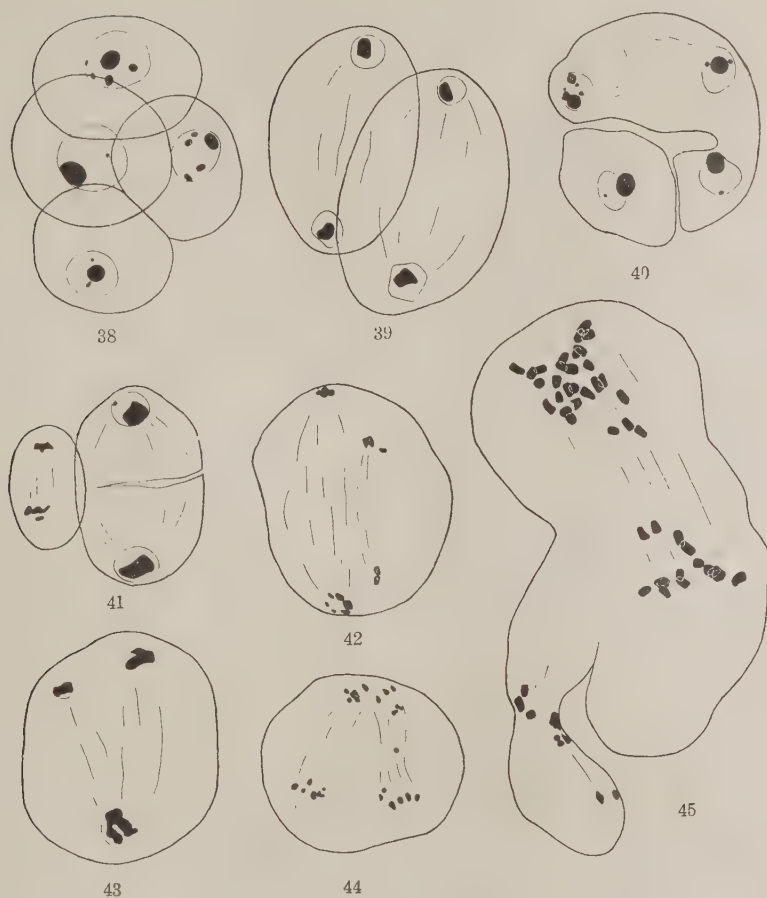
contact univalents, especially those found near the poles are no doubt brought together by chance or by poor fixation. Some of those pairs near the equator, however, are concluded to be morphologically true bivalent chromosomes. Figs. 15, 16 and 17 show some examples of the true bivalent formation. Occasionally an imperfect equatorial plate is formed by some univalent chromosomes. In Fig. 18, 7 univalents are found in the equatorial region and 2 univalents are situated on one side, and 3 univalents on the other. The univalents in the equator are constricted, looking like bivalents. The largest number of univalents ever observed in the equator was 8. In Fig. 19, 4 univalents are found near the equator, and 7 univalents on one side of that region. Fig. 20 shows a more uneven distribution of chromosomes. When the spindle is forced right against the cell wall, the chromosomes are scattered nearly on the wall. Rarely a tripolar spindle, a branched spindle (Fig. 21), and two independent small spindles were observed (Fig. 22). As already mentioned, the univalents are supposed to travel to a nearer pole. Thus 6-6 distribution was met with most frequently (Fig. 23), and 5-7, and 4-8 distributions followed in that order. When most of the univalents have approached closely to the poles, one or two of those may still loiter near the equator. The univalents which make imperfect equatorial arrangement soon show a clear splitting (Fig. 25 and 26). The size and appearance of the chromosomes seem to be affected easily by the fixation, or by later treatments (Fig. 24 and 27). A tripolar spindle distributes chromosomes to three poles to make three daughter nuclei (Fig. 33).

*Heterotypic telophase and the first cytokinesis:* The univalents which reached near the poles are soon surrounded by the nuclear membrane newly produced. The chromosome now assumes an irregular shape, and stains faintly. A large nucleolus appears again. Occasionally a few lagging chromosomes are found outside of the nucleus. By this time the spindle, which was very narrow before, increases its breadth remarkably, nearly to the point of making contact at the equator with the cell membrane. Then the cell plate is formed, and the cell division follows. In regular cases these processes proceed centrifugally. In the majority of cases, however, the cytokinesis is carried out imperfectly or in a very irregular manner. In some cases the cytokinesis does not occur at all, while in others it is suspended at various stages of progress. Fig. 29 shows slightly abnormal cytokinesis. If the process is discontinued at this stage such a cell as depicted in Fig. 32 will result. In certain cases the cytokinesis is carried out by furrowing

which proceeds to some extent independently with the nuclear division (Fig. 30 and 31).



Figs. 29-37. The first cytokinesis and homotypic nuclear division of haploid *Oryza sativa*. 29. Slightly abnormal cytokinesis. 30. Cytokinesis by furrowing. 31. Two secondary microsporocytes produced by furrowing. 32. Intermitted cytokinesis. 33. Tripolar distribution of chromosomes. 34. Giant homotypic spindle with 12 chromosomes. 35, 36. Typical homotypic spindles. 37. Lagging chromosomes in homotypic spindle.  $\times 2000$



Figs. 38-45. Homotypic nuclear division and the second cytokinesis of haploid *Oryza sativa*. 38. Tetrad cells of the most normal appearance. 39. Homotypic telophase of the most normal appearance. 40. Non-synchronous homotypic divisions in malformed cell. 41. Non-synchronous homotypic divisions in sister sporocytes of different size. 42. Parallel homotypic spindles closely appeared. 43, 44. Union of two chromosome groups in the end of homotypic division. 45. A monstrous cell occasionally found among microsporocytes.  $\times 2000$



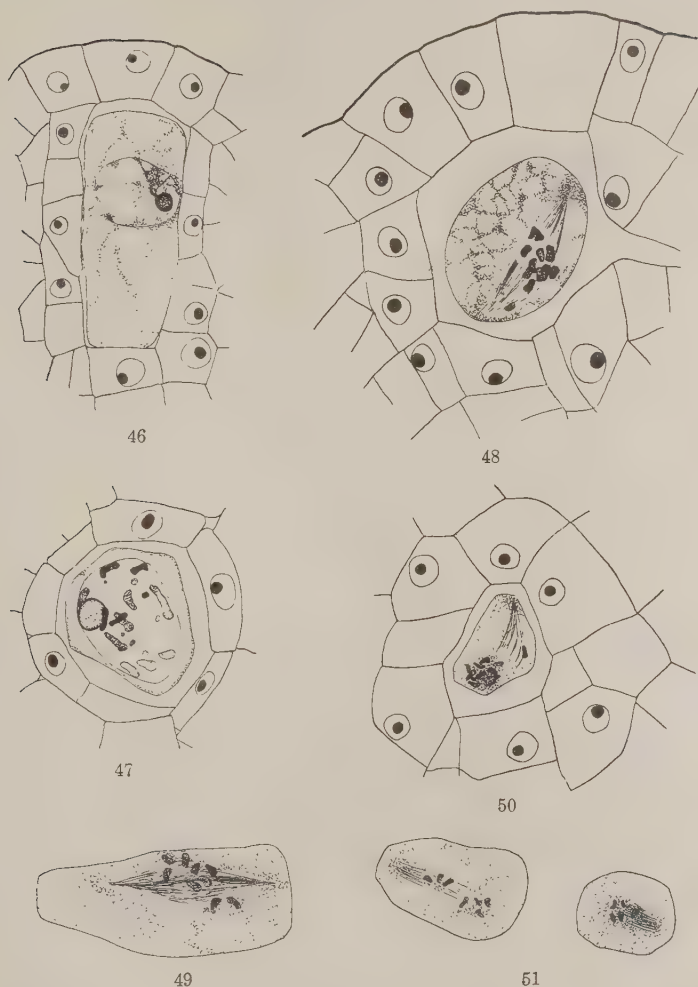
*Homotypic nuclear division and the second cytokinesis:* Owing to the preceding irregular nuclear and cell divisions, the pollen mother-cells carrying the homotypic nuclear division show fairly diverse appearances. Fig. 35 and 36 show the typical appearance of the homotypic spindles, though the cells show only the trace of the first cytokinesis. Sometimes a few lagging chromosomes are met with in the anaphase (Fig. 37). In most regular cases the homotypic nuclear divisions proceed simultaneously in the two sister sporocytes of the same size (Fig. 39). When two sister sporocytes or nuclei are obviously different in size, the division of the smaller one is delayed usually beyond that of the larger one (Fig. 41). The origin of such cells as shown in Fig. 40 will easily be understood when one compares it with Fig. 32. In a certain homotypic spindle 12 chromosomes were counted (Fig. 34). This may result from the imperfect first nuclear division or from 0-12 distribution of univalents in the heterotypic anaphase. The fusion of two homotypic spindles may also be taken into account, as the two spindles sometimes appear very closely parallel side by side (Fig. 42). Two chromosome groups out of four in the homotypic anaphase unite rarely into one group (Fig. 43 and 44). Typical tetrad cells of regular appearance are shown in Fig. 38.

In some archesporial cell divisions, chromosome division is not followed regularly by the nuclear and cell divisions. The plasmodium produced in this manner is shown in Fig. 45.

### Megasporogenesis

*Heterotypic division:* In a diakinetik nucleus, 12 univalent chromosomes are observed. Satellite-like bodies, such as those found in pollen mother-cells, were also met with in several nuclei at this stage (Fig. 47).

Owing to the nature of the material, the authors rarely came across clear figures of the heterotypic metaphase. A few perfect figures of the meta- and anaphases, obtained out of hundreds of ovaries, showed exclusively the univalent chromosomes (Fig. 48 and 49). The chromosomes seem to be distributed to either of the poles merely by chance. Fig. 51 represents an anaphasic cell in two sections, in which 3 univalents are going to one pole and 8 univalents to the other, leaving the remaining one in the middle position of the spindle. In Fig. 50 univalents are found near one pole. Such extremely uneven distribution



Figs. 46-51. Megasporogenesis of haploid *Oryza sativa*. 46. EMC in early heterotypic prophase, showing synizetic knot of chromatic threads. ( $\times 1200$ ) 47. EMC in diakinesis showing 12 univalent chromosomes, some satellite-like bodies are noticed. ( $\times 1800$ ) 48. EMC in heterotypic metaphase showing 12 univalent chromosomes. ( $\times 1800$ ) 49. A part of an EMC in heterotypic metaphase, showing the configuration of univalents. ( $\times 1800$ ) 50. EMC in late heterotypic metaphase, showing irregular distribution of univalents. 11 univalents are found on one pole of the spindle. ( $\times 1800$ ) 51. EMC in heterotypic anaphase depicted from two successive sections. ( $\times 1200$ )



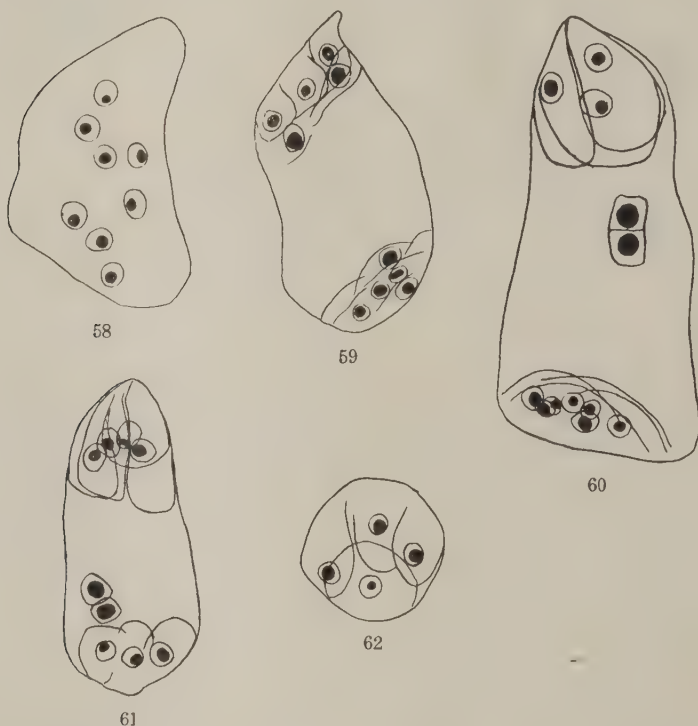
Figs. 52-57. Megasporogenesis and embryo-sac formation of haploid *Oryza sativa*. 52. EMC in heterotypic telophase. ( $\times 1200$ ) 53. EMC in late heterotypic telophase containing one large nucleus and a few small nuclei; no cell-wall formation is occurring. ( $\times 1200$ ) 54. EMC in interkinetic stage. Each cell contains micronucleus. In the upper cell cytoplasmic furrowing can be seen between a large and a small nucleus. ( $\times 1200$ ) 55, 56. EMCs in homotypic metaphase; 55 shows 7 chromosomes in the lower cell, and 56 shows 4 chromosomes in the upper cell. ( $\times 1200$ ) 57. Normal embryo sac produced by haploid; 1 egg cell, 2 synergid cells, 2 pole nuclei and 4 antipodal cells are clearly observable. ( $\times 1200$ )

is supposed to be of very rare occurrence. Two groups of chromosomes attaining to poles soon reform the daughter nuclei, which ultimately take the resting appearance producing large nucleoli. Extra micronuclei derived from the lagging chromosomes shut out of the daughter nuclei were observed not infrequently. Fig. 53 shows only one large nucleus and two micronuclei. Extremely unequal distribution of chromosomes had no doubt been effected in such a cell in the preceding anaphase. Soon after the heterotypic division of nucleus, there follows the cell wall formation. A rare case was shown in Fig. 54 where cytoplasmic furrowing had been started around a micronucleus.

*Homotypic division* : In some cases, the sister sporocytes start the homotypic division simultaneously, but more generally they carry it on one after the other. Fig. 55 and 56 represent respectively two secondary megasporocytes in different stages of division. Seven and four somewhat rod-shaped metaphasic chromosomes are counted in those figures. The homotypic division proceeds normally, to form tetrad cells in a row arrangement, though some irregularities are also met with.

*Embryo-sac formation* : In one of the tetrad cells, the nucleus divides three times successively without cell wall formation, producing eight nuclei in one cell. In which one of the tetrad cells such nuclear divisions take place is not determined. Fig. 58 shows a young embryo-sac cell containing eight naked nuclei. The nucleolus in one nucleus is clearly smaller than those in others. As the nucleus of the matured egg-cell is characterized by its small nucleolus, it is concluded that the egg nucleus is differentiated already in the stage of eight bare nuclei. Fig. 57 as well as Fig. 60 are the normally matured embryo-sacs of the haploid plant. They contain two synergid cells, one egg cell, and two pole nuclei. Though four antipodal cells are presented in these figures, the number of those cells is not constant. The authors once observed three antipodals in a very young embryo-sac, but in matured ones they usually found more than three of those cells. Fig. 59 shows a young embryo-sac in which five antipodal cells are definitely identified. The supernumeral antipodal cells are no doubt produced by the division of the primary ones. Usually the nucleus of the primary antipodal cell divides once or more, either being accompanied by cell division or not. Thus the number of nuclei in one antipodal cell was usually two or more, and in some extreme cases the number amounted to five.

The foregoing descriptions of the process of embryo-sac formation were made on exceptionally regular cases observable in the haploid plant. In a majority of cases, the process is discontinued on the way, and degeneration of the cells sets in. Usually degeneration begins soon after the reduction divisions, but in few cases it starts even in an



Figs. 58-62. Embryo-sac formation of haploid *Oryza sativa*. 58. Early stage of embryo sac formation. Eight nuclei are counted. ( $\times 1600$ ) 59, 60. Normal embryo sacs with two synergids, one egg-cell, and two pole nuclei. Number of antipodals is more than three. ( $\times 800$ ) 61, 62. A part of abnormal embryo sacs. Each shows three synergids. ( $\times 800$ )

earlier stage, i.e. before the homotypic division. Fig. 68 and 69 are the photographs of ovaries, showing the degenerated cells in their ovules. As these cells stain very deeply with haematoxylin, the number of cells and their inner aspects are not discernible.





Figs. 63-69. Ovaries of haploid *Oryza sativa*. 63. An ovary growing parthenocarpically. The trace of degenerated EMC is observable. ( $\times 45$ ) 64, 65. Ovaries growing parthenocarpically. The center cavity of ovule containing some antipodals or a few scattered nuclei is derived from embryo sac. ( $\times 45$ ) 66. Abnormal ovary with two ovules. ( $\times 90$ ) 67. Abnormal ovary with two EMCs. ( $\times 180$ ) 68, 69. Two young ovaries showing no parthenocarpic growth; embryo sacs are completely degenerated in them. ( $\times 180$ )

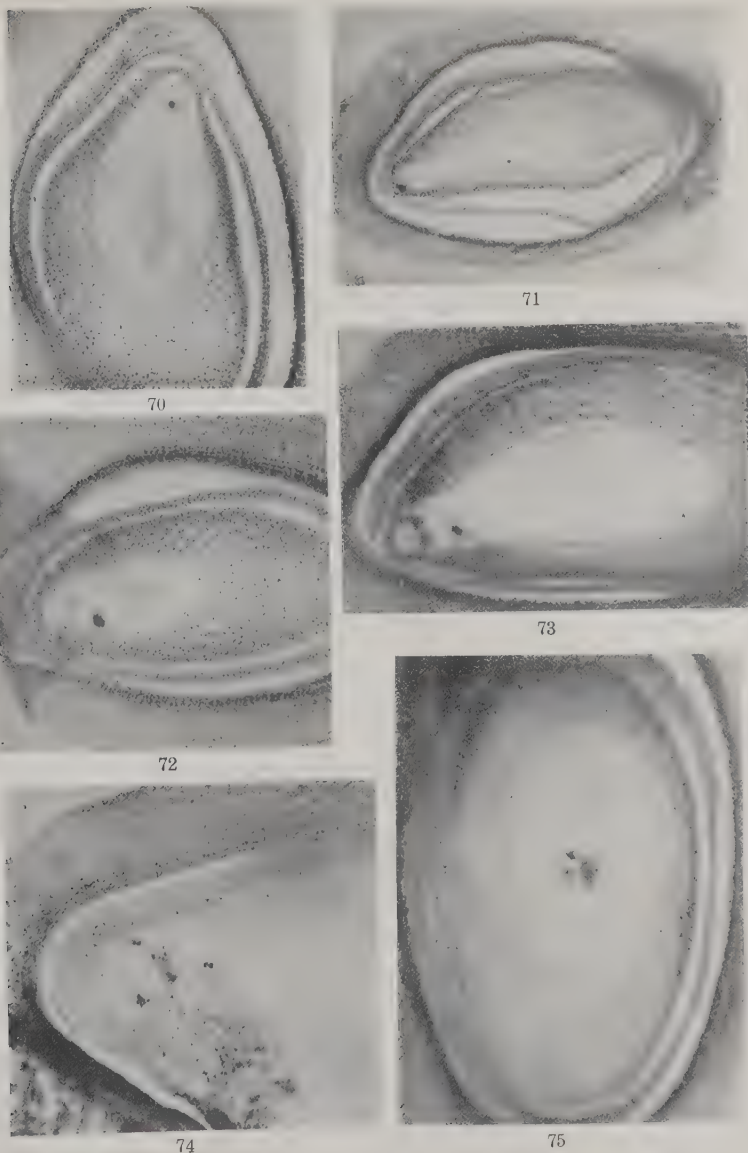


As already mentioned above, in some ovaries the megasporocyte develops into an embryo-sac. The authors examined in total 183 ovaries, of which 154 contained no embryo-sac while the remaining 29 ovaries, or 15.8% of the total, contained the embryo-sac.

In the course of these studies, the authors also observed the following malformations, which may or may not have causal connection with haploidy itself. They are: 1) an ovary containing two ovules of normal appearance (Fig. 66), 2) several ovules with two embryo-sac mother-cells (Fig. 67), 3) a few embryo-sacs which contain one extra synergid in addition to two, other apparatuses being normal (Fig. 61 and 62). All these exceptional cases have not been reported even for the diploid plant of rice.

#### Parthenocarpic development of the ovary in haploid

The ovary of the haploid containing embryo-sac starts growth without fertilization. In a majority of such cases, the ovaries are so enlarged as to fill up nearly the whole glume-cavity. Fig. 64 and 65 are the photographs of such parthenocarpically growing ovaries. Ovaries which lack the embryo-sac may also show parthenocarpic growth to some extent. The growing ovary represented in Fig. 63 shows inside only the trace of a degenerated embryo-sac. The large inner cavity, which appears in the far developed ovary, is derived from the embryo-sac, and it often contains some sac apparatuses still remaining intact or showing degeneration. This cavity enlarges with the growth of the integuments, and contains watery liquid inside. Fig. 65 shows the general appearance of the ovule in the parthenocarpic ovary. A group of cells in the center position are antipodals, and the pole nuclei and some degenerated apparatuses are found on the micropylar end of the cavity. The egg cell and synergid cells in a matured sac divide no more, and degenerate sooner or later. The pole nuclei and antipodals clearly survive the egg cell and synergid cells (Figs. 70-73). Antipodals were often observed clinging to the side wall of the cavity in a spherical mass, and in some cases the number of those cells exceeded ten. Fig. 75 shows only a part of the group of antipodal cells. In a few exceptional cases, pole nuclei divide many times. Two large and many small nuclei in Fig. 74, and many dispersed nuclei in Fig. 64 are considered to have originated from the pole nuclei.



Figs. 70-75. Ovules of haploid *Oryza sativa*. 70-73. A part of ovules in parthenocarpic growth; pole nuclei remain intact, but degeneration process is going on in synergids and egg-cells. ( $\times 180$ ) 74. Micropylar end of an ovule in parthenocarpic growth. Two large and a large number of small nuclei are observable (rare case). ( $\times 180$ ) 75. A part of antipodal cell group in an ovule in parthenocarpic growth. Some of those antipodal cells retain normal appearance. ( $\times 180$ )

### Consideration

In 1931, the first haploid plant was found by chance in a certain  $F_1$  intervarietal progeny. In the next year, the authors endeavoured to find other haploids in the offspring of various intervarietal hybrids, which were cultivated for other genetical purpose. Three haploid plants were obtained out of some 130,000 individuals. In 1933 they looked for haploid not only in the offspring of hybrids, but also in common varieties under ordinary cultivation. Three haploid plants were again obtained of which two were found in common varieties. Thus the haploid in rice seems to occur quite indifferently to hybridization, which is often regarded as an available means for causing haploid mutation.

NAKAMURA (23) obtained two haploids, one in a highly sterile mutant line, and the other in a  $F_2$  line of a hybrid between a partially sterile mutant line and a normal variety. A certain type of sterility might be favourable for causing haploid parthenogenesis. The case reported by RAMIAH and others (26) is a quite an exceptional one. They obtained twin seedlings of which one was normal, and the other was a haploid.

The frequency occurrence of the spontaneous rice haploid is roughly estimated, on the basis of observations made in 1932, as 0.0023%. The seeds set on the haploid produce only diploid plants. This may be looked upon as a reason why the haploid mutant had so long escaped the attention of genetists. In *Brassica Napella* (18) spontaneous haploid mutants occur far more frequently than in rice, but it had been overlooked until recently for the same reason. Though direct cytological observation is entirely lacking, it may be assumed that, as it is in the case of most haploids in higher plants, so the rice haploid has also arisen from the parthenogenetic development of an egg-cell. In fact Haploid I and the haploid found by NAKAMURA quite resembled their mother plants.

The haploid plant occasionally produces completely fertile diploid tillers, or diploid parts of the ear. Therefore a theoretically homozygous clone, or a pure line such as defined by JOHANNSEN is easily obtainable from the haploid. Analogous somatic chromosome doubling has never been reported in the diploid plant of rice. Diploid bud variation was also observed by HOLLINGSHEAD (6) on the haploid plant of *Crepis capillaris*.

The haploid chromosomal constitution reduces the size of every part of the plant, in various proportions, but in a similar way for all haploids of that species. Numerable characters such as tillering or the number of spikelets in unit length of ear, however, are affected by the same constitution very differently, according to the nature of the original diploid plant. For instance, the culm of a haploid is always shorter than that of the corresponding diploid, as are also the length and width of the spikelet, and the reduction for culm length is in most haploids far greater in proportion than the reduction for the length or width of the spikelet. The tillering capacity and the density of ear are affected remarkably, though in opposite ways, in Haploid I and Haploid V, but they are not affected to any noticeable extent in other haploids.

The haploid plants are extremely high in sterility in their natural condition, but if pollinated artificially with normal pollen-grains they produce seeds, though in very low percentage. Thus the highest percentage of fertility obtained was 2.41%. As all offspring plants of haploids showed 24 chromosomes in their root tip-cells, the functional megaspores must contain 12 chromosomes. The same will also be true for pollen-grains. Though the parthenocarpic growth of rice caryopsis is also observable in certain diploid sterile types (19, 22), this tendency is very strong in all the haploid plants discovered.

The mode of nuclear division in the pollen mother-cell of haploid rice plant is essentially the same as that described for the haploid in other species. The authors (17) reported in 1932 that the rice haploid revealed no bivalent chromosomes in the heterotypic division, and the same was also reported by NAKAMURA (23). More extensive studies reported in this paper, however, made it clear that the rice chromosomes can make, though rarely, 1 or 2 bivalents among themselves. Giant microspores appear rarely as a result of 0-12 distribution of univalents in the heterotypic anaphase, or by the suspension of the heterotypic division. The chance of fusion of two homotypic spindles is also conceivable in this connection. Occasionally spindle formation is affected noticeably in the heterotypic division. Not only nuclear division, but cell division is also disturbed remarkably in the haploid. Regular cell wall formation after heterotypic division is often omitted, and, though rarely, furrowing takes its place. This latter process, as reported in certain plants exposed to abnormal temperatures, seems to proceed to some extent independently of the nuclear division (29).



The reduction divisions in the embryo-sac mother-cell are carried out in the same way as in pollen mother-cells. In most of the ovaries embryo-sac formation does not occur at all, or it ceases at various stages of progress. Out of 183 ovaries examined 29 or 15.8% of the total contained the embryo-sac. As the highest fertility of the haploid was only 2.41%, it is highly probable that the majority of those embryo-sacs are not functional. A well formed embryo-sac, when found, is organized like that of a diploid plant. It contains one egg cell, two synergid cells, two pole nuclei and many multinucleated antipodal cells. The egg nucleus is differentiated soon after the third nuclear division of the megaspore nucleus. The authors observed an ovary with two ovules, and several ovules with two embryo-sac mother-cells. Such abnormalities seem to occur also in diploid individuals. Twin seedlings, rarely observed in rice, will be produced by such ovaries (11). The parthenocarpic growth of the ovary is more conspicuous when it contains an embryosac. Though the egg and synergid cells in such embryo-sacs do not divide any more, pole nuclei may divide many times successively.

It may not be superfluous to consider in this place the chromosomal constitution of *Oryza sativa*. This species is regarded as tetraploid by three investigators, namely, CHAO, LAWRENCE, and YAMAURA, for various several reasons. CHAO (4) stated in his paper on the glutinous gene in rice that the meiotic divisions in the pollen mother-cells were normal at least in three of the unrelated varieties, namely, 1000, 200, and 1300, the first being diploid, and the last two possibly tetraploid. The number 1000 is a scented non-glutinous variety grown in China.<sup>(1)</sup> Though the author did not specify the numbers of chromosomes, he no doubt assumes the variety with 24 chromosomes as tetraploid (cf 3). But it is regrettable that this important statement is not supported by any description of the cytological observations. LAWRENCE's opinion (13) that *O. sativa* is a secondary polyploid, is based chiefly on the cytological observations which were made known by KUWADA (12). This latter investigator noticed in the species a remarkable tendency of association of chromosomes in the homotypic division metaphase. Paired arrangement of chromosomes was also observed by him in the metaphase of the somatic division. LAWRENCE ascribes such association to the homology of chromosomes. Also taking into account the presence of some duplicate factors, he suggests that the species has been derived

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(1) The scented non-glutinous Chinese variety examined by the present authors possessed 24 somatic chromosomes.

from a form with 7 pairs of chromosomes. So far as the present authors have observed, no somatic chromosomes in the root-tip cell of rice make paired arrangements as described by KUWADA. In the homotypic metaphase the chromosomes show a tendency of grouping, but no such tendency is noticeable in the heterotypic metaphase. YAMAURA (31) pointed out the facts that the species in sub-families closely related to *Oryzae* contain 5 or 7 chromosomes, and suggested the origin of *Oryza* to the hybridization between 5 and 7 chromosome species.

From the present investigations on the haploid *O. sativa* it is clear that the haploid chromosome set of the species does not contain any true homologous chromosomes. A few bivalents may occur, but such occasional bivalents are also observable in diploid species such as *Triticum monococcum* (10) and *Oenothera blandina* (2), or in allopolyploid species such as *Triticum compactum* (5). If, as LAWRENCE conceives, the rice chromosomes have such a degree of affinity as to make 4 or 5 bivalents in the homotypic division of the normal plant, why do they not make the same number of bivalents in the meiotic divisions of the haploid? Granting that *O. sativa* now under cultivation is a tetraploid, it can hardly be regarded as an autotetraploid.

### Summary

1. Since 1931 the authors have discovered 7 haploid plants of rice. The haploid plant seems to occur spontaneously in common rice field, as well as in the progenies of varietal hybrids.

2. The haploid chromosomal constitution reduces the size of every part of the plant in various proportions, but in a similar way for all haploids. Numerable characters such as tillering, or the number of spikelets in unit length of ear, however, are affected by such nuclear condition very differently according to the nature of the original diploid plant.

3. The haploid plant occasionally produces completely fertile diploid tillers, or diploid parts of ear. Therefore a theoretically homozygous clone, or a pure line such as defined by JOHANNSEN is easily obtainable from the haploid.

4. The haploid plant produces almost no seeds in their natural condition, but if pollinated artificially with normal pollen-grains they produce seeds, though in very low percentage.



5. The ovary of the haploid can grow parthenocarpically. The ovary containing the embryo-sac shows a stronger tendency of parthenocarp than the ovary which lacks it.

6. The mode of nuclear division in the pollen mother-cell of the haploid is essentially the same as that described for the haploid in other species. One or two bivalents occurs occasionally in the heterotypic division metaphase. Occasionally spindle formation is affected noticeably in the heterotypic division. Not only nuclear division, but cell division is also disturbed remarkably in the haploid. Rarely normal pollen-grain is produced.

7. The reduction divisions in the embryo-sac mother-cell are carried out in the same way as in pollen mother-cells. In most of the ovaries embryo-sac formation does not occur at all, or it ceases at various stages of progress. A well formed embryo-sac, when found, is organized like that of a diploid plant.

8. An ovary with two ovules, and several ovules with two embryo-sac mother-cells were observed. Such abnormalities seem to occur also in diploid individuals.

9. Granting that *O. sativa* now under cultivation is a tetraploid, it can hardly be regarded as an autotetraploid.

PLANT-BREEDING LABORATORY,  
KYUSHU IMPERIAL UNIVERSITY.

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  31. YAMAURA, A., 1933. Karyologische und embryologische Studien über einige Bambus-Arten (Vorläufige Mitteilung) (in Japanese). Bot. Mag. Tokyo **47**: 551-555.
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# Über das Vorkommen und die Bedeutung der Wurzepilze in den Landpflanzen

Von Tōichi ASAI

(Mitteilung aus dem botanischen Laboratorium der Fünften  
Höheren Schule zu Kumamoto)

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Mit 13 Textfiguren

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## Einleitung

Das Mykorrhiza-Problem ist ein in der Botanik schon lange bekanntes. In der Mitte des vorigen Jahrhunderts wurde das Pilzmyzel in den Wurzelzellen von SCHLEIDEN<sup>(1)</sup> bei *Neottia Nidus* gefunden, und im Jahre 1882 gab KAMIENSKI<sup>(2)</sup> den echten Pilz an der Wurzel von *Monotropa* an. Bald darauf wurde das Interesse auf den Wurzepilz in den humusreichen Wäldern gelenkt; FRANK<sup>(3)</sup> wies die weitere Mykorrhizaverbreitung bei Coniferen, Betulaceen und Fagaceen nach, bemerkte eine innige Vereinigung zwischen dem Pilz und der Wurzel der höheren Pflanzen, und unterschied seine sogenannte Mykorrhiza in zwei Formen, ektotrophe und endotrophe. Um eine symbiotische Vereinigung mit dem Wurzepilz bei einer Anzahl von höheren Pflanzen zu erklären, beschäftigten sich viele Forscher bisher in bezug auf die Mykorrhiza mit verschiedenen Untersuchungen. Trotz darauf begründeten zahlreichen Arbeiten und mannigfaltigen Ansichten, ist doch diese Erscheinung heute noch als höchst problematische Frage übrig geblieben. Wir haben in den Hauptzügen die ektotrophe Mykorrhiza

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(1) SCHLEIDEN, M. J., Grundzüge der wissenschaftl. Botanik. Leipzig, 1849.

(2) KAMIENSKI, F., Organes végétatifs du *Monotropa Hypopitys* in Mém. Soc. nat. Cherbourg **24**, 1882.

(3) FRANK, B., Über die auf Wurzelsymbiose beruhende Ernährung gewisser Bäume durch unterirdische Pilze. Ber. Deutsch. Bot. Ges., **3**, 1885.—Über die physiologische Bedeutung der Mykorrhiza. Ebenda, **6**, 1888.

durch den Synthesenversuch von MELIN<sup>(1)</sup> in neuerer Zeit wirklich erkannt, doch über die endotrophe haben wir bis jetzt noch keine bestimmte Kenntnis, selbst darüber, zu welcher Stellung der Wurzelpilz systematisch gehört. Immerhin soll das Zentrum des Mykorrhizaproblems in der Tat in dieser Richtung liegen.

Das Vorkommen des Endophytes in den Wurzeln ist bisher selbst nur stückweise, etwas weiter bei den höheren Pflanzen bekannt und bis zu solchen nachgewiesen worden, die in der tropischen und arktischen Gegend verbreitet sind. Doch die endotrophe Mykorrhiza ist nach meiner Ansicht nicht als eine Erscheinung in so engem Sinne zu beschränken, dehnt sich vielmehr über alle Landpflanzen mit nur wenigen Ausnahmen allgemein sehr weit aus. Während ich in letzter Zeit in bezug auf die Mykorrhiza der Kraterpflanzen gearbeitet habe, habe ich bemerkt, dass die Mykorrhiza nicht immer eine seltene Erscheinung ist, ja der Wurzelpilz in den dünnen Wurzeln ebenso weit vorkommt, wie wir die Landpflanzen ohne Mykorrhiza selten finden. Wird solche Tatsache aber wirklich nachgewiesen, dann soll die eigentliche symbiotische Vereinigung bezüglich der Ernährungsphysiologie eine ziemlich grosse Rolle bezüglich der höheren Pflanzen spielen. Es ist auch nicht ohne Interesse zu untersuchen, was die systematische Stellung und die Standorte der Wirtspflanzen betreffs Mykorrhizabildung bedeuten.

Ich spreche hier meinem Assistenten, Herrn M. YAMASCHIRO, für seine wertvolle Hilfe meinen besten Dank aus.

### Das Vorkommen des Wurzelpilzes in den Landpflanzen

Es ist eine schon lange bekannte Tatsache, allerdings nur teilweise, dass eigentliche Pilze mit einem symbiotischen Verhältnis in den Wurzeln der höheren Pflanzen ziemlich weit verbreitet sind und diese Mykorrhizen von der tropischen bis zur arktischen Gegend verbreitet sind, auch auf das alpine Gebiet sich erstrecken, doch haben wir keine Kenntnis über ihr weiteres Vorkommen in den dünnen Wurzeln aller Landpflanzen.

Unter den Farnpflanzen gibt es einige Arten, deren Gametophyt mit dem mykorrhizaähnlichen Gebilde in seiner unterirdischen Knolle saprophytisch lebt wie das pilzbewohnende Prothallium von *Ophioglos-*

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(1) MELIN, E., Untersuchungen über die Bedeutung der Baummykorrhiza. Jena 1925.



*sum*, *Botrychium*, *Lycopodium* und *Psilotum*<sup>(1)</sup>; dasselbe Verhältnis haben wir auch an grünem Prothallium von Marattiaceen<sup>(2)</sup> kennen gelernt. An den Sporophyten von *Dicksonia* und *Cyathea* ist die typische Mykorrhiza bekannt. Die endotrophe Mykorrhiza bei Gymnospermen wurde an den Taxodien, Araucarien, Cupressineen nachgewiesen<sup>(3)</sup>, insbesondere wurde es durch einige Forscher an den Wurzelknöllchen von *Podocarpus*, aufmerksam gemacht. Auf den Blütenpflanzen, an denen endophytische Myzelfäden in ihren Wurzeln festgestellt worden sind, können wir folgende Gattungen zählen: *Asarum*, *Sempervivum*, *Empetrum*, *Acer*, *Vitis*, *Erythraea*, *Molinia*, *Bambus*-Arten, ferner einige zu den Rosaceen, Asclepiadaceen und Liliaceen gehörende<sup>(4)</sup>. Vor allem sind die Mykorrhizen von Ericaceen<sup>(5)</sup> und Orchideen<sup>(6)</sup> bisher lange bearbeitet worden, und zur Kenntnis der Orchideenmykorrhiza verdanken wir insbesondere viel den Forschungen von BERNARD und BURGEFF.

FABER<sup>(7)</sup> gab vor kurzem in seiner Untersuchung über die Solfataren-Pflanzen in Westjava an, dass viele Solfataren-Pflanzen ein allgemeines Merkmal, die Mykorrhiza zu bilden, besitzen, um sich ihrem

(1) BRUCHMANN, H., Über das Prothallium und die Keimpflanze von *Ophioglossum vulgatum*. Bot. Zeit. **62**, 1904; Das Prothallium von *Lycopodium*. Bot. Zentralb. **21**, 1885. JEFFREY, E. C., The gametophyte of *Botrychium virginianum*. Transact. of the Canad. Inst., **5**, 1896/97. DARNELL-SMITH, G. P., The gametophyte of *Psilotum*. Transact. R. Soc. Edinb., **52**, 1918.

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(5) TERNETZ, CH., Assimilation des atmosphärischen Stickstoffs durch Pilze. Jahrb. f. wiss. Bot., **44**, 1907. RAYNER, M. C., Obligate symbiosis in *Calluna vulgaris*. Ann. of Bot., **29**, 1915. DUFRÉNOY, I., The endotrophic mycorrhiza of Ericaceae. The new phytol. **16**, 1917.

(6) BERNARD, N., L'évolution dans la symbiose. Ann. Sci. Nat., Bot, **9**, 1909. BURGEFF, H., Die Wurzelpilze der Orchideen. Jena 1909. WOLFF, H., Zur Physiologie des Wurzelpilzes von *Neottia Nidus avis* RICH. und einigen grünen Orchideen. Jahrb. f. wiss. Bot. **66**, 1926.

(7) FABER, FR., Untersuchung über die Physiologie der javanischen Solfataren-Pflanzen. Flora **18-19**, 1925.

besonderen Standort gut anzupassen. Obwohl in tropischer Gegend, die Lage dieser Solfataren ist in Höhe von 2500 m über Meer, gehört die Hälfte der in Frage kommenden Pflanzen zu den Ericaceen. Danach fragte ich mich, ob man zu demselben Ergebnis bei den Kraterpflanzen auf dem Vulkan Aso (1592 m) gelangen könne, und unerwartet fand ich die typische endotrophe Mykorrhiza an zwei Gräsern, *Calamagrostis autumnalis* und *Miscanthus Matsumurae* (Fig. 1), welche in der Nähe des Kraters auftreten. Im Laufe meiner Untersuchung aber war die Mykorrhiza nicht ein so seltenes Gebilde für uns, dass wir Mühe hatten, es aufzufinden; natürlich gehen die

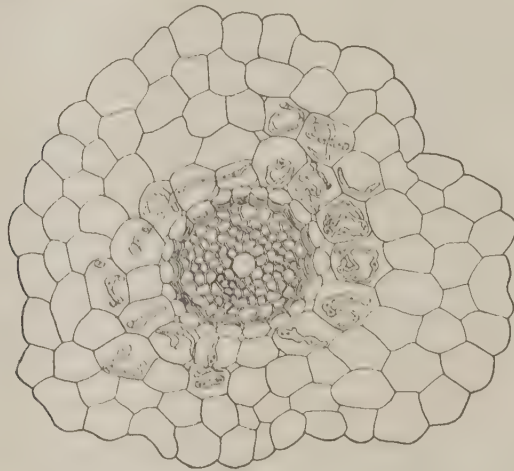


Fig. 1. Querschnitt der dünnen Wurzel von *Miscanthus Matsumurae* am 21. Okt. Vergr. 200-fach.

Kraterpflanzen die Mykorrhiza nichts an. Nach STAHL<sup>(1)</sup> sind die Mykorrhizapflanzen mindestens ebenso zahlreich wie die mykorrhiza-freien, ja alle Landpflanzen führen in der Natur stets den Wurzelpilz ebenso häufig, wie der Flechtenpilz immer in symbiotischer Vereinigung die Algen begleitet; überdies ist er endotroph ausser einem Teil. In der Tat ist die Mykorrhiza als Merkmal nicht den Landpflanzen zu überlassen.

(1) STAHL, E., Der Sinn der Mykorrhizenbildung. *Jahrb. f. wiss. Bot.* **34**, 1900.

Um die An- und Abwesenheit des Myzelfadens in der Wurzelrinde wirklich nachzuweisen, habe ich sehr dünne Wurzeln gewöhnlich von etwa 0,2–0,3 mm Durchm. angewendet. Wo der Pilzsymbiont in der Wurzel wohnt, ist er von der Wurzelhaarzone bis zur Wachstumszone beschränkt. Es ist etwas Fertigkeit nötig, um den Schnitt aus dem ganz dünnen Wurzelteil mit freier Hand auszuführen, auch darf man, um auf die Sammlung des Beweismaterials genügend achtzugeben, die sehr feinen Teile der Wurzel nicht verletzen. Zu diesem Zweck sind die jungen Pflanzen insbesondere der Bäume gut brauchbar, um dünne Wurzeln völlig zu gewinnen; bei den Kräutern ist das Stadium vor der Blütenzeit vorzuziehen. In den Exemplaren, welche von der Wurzelhaarzone etwas entfernt entnommen oder zur unpassenden Jahreszeit gesammelt werden, ist der Pilzsymbiont in den Rindenzellen nicht immer in dem Myzelfaden, sondern in verschiedenen Verdauungsstufen vorhanden, wie in dem klumpigen oder zerfallenen Zustand, häufig auch als eine aufgelöste gelbe Masse; so dass die Identifizierung des Mykorrhizapilzes in den Zellen dabei zum Anfang nicht leicht ist.

Die Mykorrhiza bei den Pteridophyten und Gymnospermen wurden an folgenden Arten konstatiert:

<i>Botrychium ternatum</i> SW.	Endophyt	pH 5.66	24. Juni
<i>Ophioglossum nudicaule</i> L. f.	"	5.62	24. "
<i>Cyathea spinulosa</i> WALL.	"	5.35	16. Juli
<i>Pteridium aquilinum</i> KUHN.	"	5.62	20. Juni
<i>Ceratopteris thalictroides</i> BRONGH.	Myzel fehlt	5.10	7. Aug.
<i>Gleichenia linearis</i> CLARKE.	Endophyt	5.50	8. Juli
<i>Lygodium japonicum</i> SW.	"	5.52	"
<i>Osmunda regalis</i> L. var. <i>japonica</i> MILDE.	"	5.66	"
<i>Marsilia quadrifolia</i> L.	Myzel fehlt	5.20	3. Juli
<i>Equisetum arvense</i> L.	"	5.57	5. "
<i>Equisetum hyemale</i> L.	"	5.32	"
<i>Lycopodium clavatum</i> L.	Endophyt	5.66	24. Juni
<i>Selaginella uncinata</i> SPRING.	"	5.40	21. "
<i>Isoetes japonica</i> AL. BR.	Myzel fehlt	5.20	9. Juli
<i>Cycas revoluta</i> THUNB.	Endophyt	5.95	15. "
<i>Ginkgo biloba</i> L.	"	5.60	3. "
<i>Podocarpus macrophylla</i> DON, subsp. <i>Maki</i> SIEB.	"	5.66	23. Juni
<i>Taxus baccata</i> L. subsp. <i>cuspidata</i> PILG.	"	5.62	8. Aug.
<i>Chamaecyparis obtusa</i> SIEB. et ZUCC.	"	5.67	14. Sept.
<i>Cryptomeria japonica</i> DON.	"	5.67	10. Aug.
<i>Pinus Thunbergii</i> PARL.	Ektophyt	5.66	23. Juni
<i>Ephedra vulgaris</i> RICH. var. <i>helvetica</i> HOOK. et THOMS.	Endophyt	5.99	25. Juli

Dass die endotrophen Mykorrhizen an dem Sporophyt der Farnpflanzen festgestellt werden, ist bisher nicht so sehr bekannt; sogar sind nach der Ermittlung von STAHL die Arten von Polypodiaceen und Equisetaceen mykorrhizafrei. Die Schachtelhalme sind keine seltene, weit verbreitete Landpflanzen, doch konnte ich bei ihnen auch nicht den Wurzelpilz nachweisen, obwohl die genannte Pflanze zu anderen Jahreszeiten einer erneuten Prüfung unterworfen wurde. Die Farnpflanzen unserer Gegend sind in der Regel mykotroph (Fig. 2), mit Ausnahme von den wasserlebenden Farnen wie *Ceratopteris thalictroides*, *Marsilia quadrifolia* und *Isoetes japonica*; also zeigen meine Resultate in diesem Punkt eine grosse Abweichung von denen STAHLs.



Fig. 2. Querschnitt der dünnen Wurzel von *Pteridium aquilinum* am 22. Juni. Vergr. 200-fach.

Ausser einem Symbiont in der Luftwurzel ist nichts bei *Cycas revoluta* für die endotrophen Mykorrhiza sicher bekannt; aber ich habe gut entwickelten Wurzelpilz an wildwachsender *Cycas* auf Ryukyu klar feststellen können. Der Ektophyt von Kiefern wurde seit dem Fund von FRANK weiter physiologisch und ökologisch näher aufgehehlt<sup>(1)</sup>; anderseits ist der Endophyt an *Ginkgo*, *Podocarpus* und *Taxus* bekannt, vor allem ist die Knöllchenbildung durch diesen echten

(1) MELIN, E., Über die Mykorrhizapilze von *Pinus silvestris* und *Picea Abies*. Svensk Bot. Tidskr., **15**, 1921. MASUI, K., A study of the ectotropic mycorrhiza of woody plants. Mem. Coll. Sci. Kyoto Imp. Univ. **3**, 1927.

Pilz bei den *Podocarpus*-Arten eine seltene Erscheinung. Es ist hier hinzuzufügen, dass bei Gymnospermen die endotrophe Mykorrhiza auch im ganzen viel häufiger als die ektotrophe vorkommt.

Wenn die Mykorrhiza in den Blütenpflanzen sehr weit verbreitet ist, so ragen sie nicht nur durch die reichlichen Arten hervor, sondern es kommen auch noch für die Pflanzenarten, die in naher Verwandtschaft in der systematischen Stellung stehen, die biologisch auffallende Umwandlung nach den Standorten zum Vorschein; also liefern sie uns dafür den wichtigen Anhalt, das Verhältnis des Pilzsymbionts zu der Wirtspflanze richtig zu lösen. Das Beweismaterial, das sich so weit wie möglich auf die gesamten Blütenpflanzen erstreckt, wurde in der Nähe unseres Laboratoriums gesammelt. Da die Wurzeln aus sehr beschränktem Umkreis gesammelt worden sind, so spielt unter allen beherrschenden Faktoren ihr Standort fast keine Rolle, wogegen ihre systematische Verwandtschaft weit voneinander abweicht. Die Wasserstoffionenkonzentration im Boden zeigte pH 5.0–6.0 und keine grosse Abweichung. Unsere Untersuchung wurde vornehmlich im Juni und Juli durchgeführt. Eine Übersicht über An- und Abwesenheit des Wurzelpilzes in den Blütenpflanzen ist die folgende:

#### Mykorrhizapflanzen bei den Dikotylen

<i>Houttuynia cordata</i> THUNB.	Endophyt	pH 5.57	30. Juni
<i>Chloranthus japonicus</i> SIEB.	„	5.69	3. Juli
<i>Populus pyramidalis</i> SALISB.	Ektophyt	5.66	1. Juli
<i>Salix purpurea</i> L. subsp. <i>eupurpurea</i> SCHN.			
var. <i>sericea</i> KOCH	„	5.51	30. Juni
<i>Myrica rubra</i> SIEB. et ZUCC. var. <i>rubra</i> MAK.	Endophyt	5.50	23. Okt.
<i>Juglans Sieboldiana</i> MAXIM.	„	5.66	1. Juli
<i>Corylus heterophylla</i> FISCH. var.			
japonica KOIDZ.	Ektophyt	5.62	20. Juni
<i>Pasania cuspidata</i> OERST.	„	5.56	2. Juli
<i>Quercus aliena</i> BLUME	„	5.64	1. Juli
<i>Quercus glauca</i> THUNB.	„	5.66	„
<i>Abelicea hirta</i> SCHN.	Endophyt	5.67	30. Juni
<i>Ulmus parvifolia</i> JACQ.	„	5.65	„
<i>Morus alba</i> L.	„	5.67	„
<i>Boehmeria grandiflora</i> WEDD.	Myzel fehlt	5.45	1. Juli
<i>Boehmeria nivea</i> HOOK. et ARN.	„	5.62	3. Juli
<i>Helicia cochinchinensis</i> LOUR.	Endopeyt	5.66	1. Juli
<i>Thesium chinense</i> TURCZ.	„	5.57	10. Aug.
<i>Schoepfia jasminodora</i> SIEB. et ZUCC.	„	5.50	2. Juli
<i>Asarum Blumei</i> DUCH.	„	5.69	3. Juli



<i>Polygonum Blumei</i> MEISN.	Myzel fehlt pH 5.61	28. Juni
<i>Polygonum orientale</i> L.	„ 5.47	„
<i>Polygonum virginianum</i> L. var. <i>filiforme</i> NAK.	„ 5.50	29. Juli
<i>Chenopodium album</i> L.	„ 5.32	30. Juni
<i>Achyranthes bidentata</i> BL.	„ 5.62	1. Juni
<i>Mirabilis Jalapa</i> L.	„ 5.35	3. Juli
<i>Phytolacca decandra</i> L.	„ 5.71	„
<i>Mollugo stricta</i> L.	„ 5.45	2. Juli
<i>Portulaca grandiflora</i> HOOK.	„ 5.34	1. Juli
<i>Portulaca oleracea</i> L.	„ 5.45	28. Juni
<i>Dianthus chinensis</i> L.	„ 5.49	2. Juli
<i>Nymphaea odorata</i> Ait.	„ 5.20	3. Juli
<i>Cercidiphyllum japonicum</i> SIEB. et ZUCC.	Endophyt 5.66	1. Juli
<i>Paeonia albiflora</i> PALL.	„ 5.37	27. Juni
<i>Ranunculus ternatus</i> THUNB.	„ 5.67	5. Juli
<i>Akebia quinata</i> DECNE.	„ 5.69	28. Juni
<i>Nandina domestica</i> THUNB.	„ 5.62	20. Juni
<i>Cocculus trilobus</i> DC.	„ 5.65	1. Juli
<i>Magnolia grandiflora</i> L.	„ 5.64	20. Juni
<i>Meratia praecox</i> REHD. et WILS.	„ 5.62	30. Juni
<i>Cinnamomum Camphora</i> NEES. et EBERM.	„ 5.64	20. Juni
<i>Macleya cordata</i> R. BR.	„ 5.32	24. Juni
<i>Arabis flagellosa</i> MIQ.	Myzel fehlt 5.48	27. Juni
<i>Nasturtium indicum</i> DC.	„ 5.57	29. Juni
<i>Sedum kamschaticum</i> FISCH.	Endophyt 5.71	3. Juli
<i>Sedum oryzifolium</i> MAK.	„ 6.82	20. Juni
<i>Hydrangea opuloides</i> K. KOCH var. <i>pubescens</i> SCHNEID. f. <i>Hortensia</i> MAXIM.	„ 5.64	27. Juni
<i>Pittosporum Tobira</i> AIT.	„ 5.66	1. Juli
<i>Hamamelis japonica</i> SIEB. et ZUCC.	„ 5.62	30. Juni
<i>Prunus pseudo-cerasus</i> LINDL.	„ 5.64	„
<i>Albizzia Julibrissin</i> DURRAZ.	„ 5.66	21. Juni
<i>Lotus corniculatus</i> L.	„ 5.57	„
<i>Geranium nepalense</i> SWEET.	„ 5.45	3. Juli
<i>Oxalis corniculata</i> L.	„ 5.55	28. Juni
<i>Poncirus trifoliata</i> RAFIN.	„ 5.62	20. Juni
<i>Picrasma quassioides</i> BENN.	„ 5.67	3. Juli
<i>Melia Azedarach</i> L. var. <i>japonica</i> MAK.	„ 5.62	30. Juni
<i>Polygala japonica</i> HOUTT.	„ 5.50	2. Juli
<i>Daphniphyllum macropodum</i> MIQ.	„ 5.66	27. Juni
<i>Buxus japonica</i> MUELL. ARG.	„ 5.62	4. Juli
<i>Rhus javanica</i> L.	„ 5.64	27. Juni
<i>Rhus succedanea</i> L.	„ 5.51	„
<i>Ilex latifolia</i> THUNB.	„ 5.66	30. Juni
<i>Evonymus europaea</i> L. var. <i>Hamiltoniana</i> MAXIM.	„ 5.53	1. Juli
<i>Euscaphis japonica</i> PAX.	„ 5.50	„
<i>Acer palmatum</i> THUNB.	„ 5.62	30. Juni
<i>Aesculus turbinata</i> BLUME	„ 5.52	1. Juli

<i>Koelreuteria paniculata</i> LAXM.	Endophyt	pH 5.50	1. Juli
<i>Sabia japonica</i> MAXIM.	"	5.66	27. Juli
<i>Impatiens Balsamina</i> L.	"	5.32	1. Juni
<i>Berchemia racemosa</i> SIEB. et ZUCC.	"	5.62	3. Juli
<i>Vitis Thunbergii</i> SIEB. et ZUCC.	"	5.51	1. Juli
<i>Tilia Miqueliana</i> MAXIM.	"	5.65	30. Juni
<i>Hibiscus mutabilis</i> L.	"	5.66	26. Juni
<i>Firmiana platanifolia</i> R. BR.	"	5.69	30. Juni
<i>Thea japonica</i> NOIS.	"	5.65	29. Juni
<i>Hypericum chinense</i> L.	"	5.50	2. Juli
<i>Viola Patrini</i> DC. var. <i>chinensis</i> GING.	"	5.57	28. Juni
<i>Begonia semperflorens</i> LINK et OTTO	"	5.41	3. Juli
<i>Epiphyllum truncatum</i> HAW.	"	5.43	30. Juni
<i>Daphne odora</i> THUNB.	"	5.51	"
<i>Elaeagnus umbellata</i> THUNB.	"	5.60	20. Juni
<i>Lagerstroemia indica</i> L.	"	5.62	4. Juli
<i>Lythrum Salicaria</i> L. subvar. <i>genuina</i> KOEHNE	"	5.37	30. Juni
<i>Punica Granatum</i> L.	"	5.54	27. Juni
<i>Eucalyptus globulus</i> LABILL.	"	5.66	2. Juli
<i>Melastoma candidum</i> DON	"	5.67	28. Juni
<i>Ludwigia ovalis</i> MIQ.	"	5.20	9. Juli
<i>Oenothera biennis</i> L.	"	5.32	30. Juni
<i>Trapa natans</i> L.	Myzel fehlt	4.90	5. Juli
<i>Aralia cordata</i> THUNB.	Endophyt	5.32	24. Juni
<i>Heracleum lanatum</i> MICHX.	"	5.71	28. Juni
<i>Cornus brachypoda</i> C. A. MEY.	"	5.66	30. Juni
<i>Shortia soldanelloides</i> MAK. var. <i>genuina</i> MAK. f. <i>typica</i> MAK.	"	5.73	28. Mai
<i>Clethra barbinervis</i> SIEB. et ZUCC.	"	5.57	25. Aug.
<i>Pirola japonica</i> MAK.	"	5.40	2. Juli
<i>Pieris ovalifolia</i> DON. var. <i>elliptica</i> REHD. et WILS.	"	5.64	23. Juni
<i>Rhododendron kiusianum</i> MAK.	"	4.95	"
<i>Vaccinium bracteatum</i> THUNB.	"	5.50	28. Juni
<i>Ardisia crispa</i> DC.	"	5.67	22. Juni
<i>Lysimachia clethroides</i> DUBY.	"	5.32	26. Juni
<i>Diospyros Lotus</i> L.	"	5.62	30. Juni
<i>Symplocos lucida</i> SIEB. et ZUCC.	"	5.50	2. Juli
<i>Styrax Obassia</i> SIEB. et ZUCC.	"	5.66	30. Juni
<i>Jasminum odoratissimum</i> L.	"	5.54	"
<i>Mitrasacme polymorpha</i> R. BR.	"	5.53	3. Juli
<i>Limnanthemum nymphoides</i> LINK. var. <i>japonica</i> MIQ.	Myzel fehlt	5.40	19. Aug.
<i>Suertia bimaculata</i> HOOK. et ARN.	Endophyt	5.51	3. Juli
<i>Nerium odorum</i> SOLAND.	"	5.52	27. Juni
<i>Cynanchum amplexicaule</i> HEMSL.	"	5.38	1. Juli
<i>Calystegia sepium</i> R. BR. var. <i>japonica</i> MAK.	"	5.55	"
<i>Phlox paniculata</i> L.	"	5.40	3. Juli

<i>Ehretia acuminata</i> R. BR.	Endophyt	pH 5.66	1. Juli
<i>Verbena officinalis</i> L.	„	5.57	30. Juni
<i>Thymus Serpyllum</i> L. var. <i>vulgaris</i> BENTH.	„	5.36	26. Juni
<i>Nierembergia gracilis</i> HOOK.	„	5.37	30. Juni
<i>Digitalis purpurea</i> L.	„	5.32	26. Juni
<i>Campsis chinensis</i> BOSS.	„	5.66	27. Juni
<i>Conandron ramondiioides</i> SIEB. et ZUGC.	„	5.41	3. Juli
<i>Gloxinia speciosa</i> B. REG.	„	5.49	6. Juli
<i>Justicia procumbens</i> L.	„	5.54	2. Juli
<i>Phryma leptostachya</i> L.	„	5.40	4. Juli
<i>Plantago major</i> L. var. <i>asiatica</i> DECNE.	„	5.57	28. Juni
<i>Gardenia jasminoides</i> ELLIS	„	5.47	2. Juli
<i>Paederia tomentosa</i> BLUME	„	5.60	1. Juli
<i>Lonicera Morrowii</i> A. GRAY	„	5.64	30. Juni
<i>Patrinia scabiosaefolia</i> LINK	„	5.71	2. Juli
<i>Scabiosa japonica</i> MIQ.	„	5.39	26. Juni
<i>Trichosanthes japonica</i> REGEL.	„	5.60	1. Juli
<i>Campanula punctata</i> LAM.	„	5.32	27. Juni
<i>Chrysanthemum indicum</i> L.	„	5.71	24. Juni

### Mykorrhizapflanzen bei den Monokotylen

<i>Typha latifolia</i> L.	Myzel fehlt	pH 4.85	5. Juli
<i>Sparganium glomeratum</i> LAEST.	„	4.95	25. Aug.
<i>Potamogeton crispus</i> L.	„	5.15	5. Juli
<i>Najas graminea</i> DEL.	„	5.15	„
<i>Alisma Plantago</i> L. var. <i>angustifolium</i> KUNTH	„	4.90	„
<i>Hydrilla verticillata</i> ROYL. var. <i>Roxburghii</i> CASP.	„	5.15	1. Juli
<i>Ottelia alismoides</i> PERS.	„	5.15	„
<i>Miscanthus Matsumurae</i> HACK.	Endophyt	4.95	8. Okt.
<i>Carex breviculmis</i> R. BR. var.			
<i>Rovleana</i> KUEK.	Myzel fehlt	5.57	4. Mai
<i>Cyperus amuricus</i> MAXIM.	„	5.37	19. Juni
<i>Cyperus rotundus</i> L.	„	5.45	„
<i>Trachycarpus excelsus</i> MAK.			
var. <i>typicus</i> MAK.	Endophyt	5.66	19. Juni
<i>Acorus Calamus</i> L.	Myzel fehlt	5.32	„
<i>Acorus gramineus</i> AIT.	„	5.34	„
<i>Colocasia antiquorum</i> SCHOTT.	„	5.50	21. Juni
<i>Commelina communis</i> L.	„	5.45	1. Juli
<i>Pollia japonica</i> THUNB.	„	5.35	22. Aug.
<i>Tradescantia virginica</i> L.	„	5.47	19. Juni
<i>Monochoria Korsakowii</i> REGEL et MAACK.	„	5.15	5. Juli
<i>Juncus effusus</i> L. var. <i>decipiens</i> BUCH.			
f. <i>intermedia</i> BUCH.	„	5.49	19. Juni
<i>Luzula campestris</i> DC. var. <i>capitata</i> MIQ.	„	5.57	5. Mai
<i>Stemona japonica</i> MIQ.	Endophyt	5.64	20. Juni

<i>Hemerocallis minor</i> MILL.	Endophyt	pH 5.47	19. Juni
<i>Polygonatum latifolium</i> DESF.			
var. <i>commutatum</i> BAK.	„	5.38	21. Juni
<i>Yucca filamentosa</i> L.	„	5.45	19. Juni
<i>Agave rigida</i> MILL.	„	5.64	„
<i>Dioscorea japonica</i> THUNB.	„	5.40	„
<i>Sisyrinchium Bermudianum</i> L.	„	5.57	„
<i>Musa Basjoo</i> SIEB. et ZUCC.	„	5.64	„
<i>Zingiber Mioga</i> ROSC.	„	5.40	20. Juni
<i>Canna indica</i> L. var. <i>orientalis</i> HOOK. f.	„	5.49	19. Juni
<i>Bletia hyacinthina</i> R. BR.	„	5.52	20. Juni
<i>Spiranthes australis</i> LINDL.	„	5.57	„

Wir bemerken einige Ausnahmen bei systematisch verhältnismässig niedrigen Gruppen, aber in den Dikotylen werden die Landpflanzen der höheren Klassen im allgemeinen von endotrophem Wurzelpilz bewohnt; die zu den Sympetalen gehörigen sind vor allem die typischen mykotrophen Pflanzen. Über die Mykorrhiza bei tropischer *Casuarina* schrieb MIEHE schon nach der knöllchenartigen Bildung von *Casuarina equisetifolia*; aber ich habe auch dabei im gewöhnlichen dünnen Teil der Wurzeln den Endophyt auf Ryukyu gefunden. Wir können nach der Anwesenheit des endophytischen Wurzelpilzes an *Houttuynia* und *Chloranthus* leicht feststellen. Man erinnert sich diesbezüglich zuerst bei *Monotropa* an die ektotrophe Mykorrhiza bei den Blütenpflanzen. Die ektotrophe Mykorrhiza ist von früher bei Salicaceen, Betulaceen und Fagaceen wohl bekannt; überdies habe ich diesbezüglich bei Juglandaceen nachgeforscht und gleichzeitig den endophytischen Wurzelpilz nachgewiesen. Aber die Verbreitung der ektotrophen Mykorrhiza in den Blütenpflanzen beschränkt sich im Vergleich zu der der endotrophen, auf einige wenige Pflanzengruppen, die sich in ihrer systematischen Stellung einander nähern. Diese Tatsache, welche wir nur von biologischer Seite bisher angesehen haben, gilt jedoch als ein Merkmal für systematische Verwandtschaft. In bezug auf die systematische Stellung der Mykorrhizapflanzen gibt es noch einen anderen interessanten Beweis, dass die Kräuter sowohl bei den Polygonalen wie den Centrospermen stets in den Wurzeln ohne Myzel sind. Diese alle sind ein Teil von den gewöhnlichsten Kräutern, welche auf dem Land gut angepasst sind und deren Verbreitung auch nicht immer eng beschränkt ist, trotzdem sie unter anderen mykotrophen Pflanzen allein die Mykorrhiza in keinen Fall bilden. Ausserdem kommt der Wurzelpilz wieder an Urticaceen, Nymphaeaceen und Cruciferen nicht vor, und diese Familien gehören

eher zu derjenigen Pflanzengruppe, die in näherer Beziehung zu den erwähnten beiden Reihen steht. Die Prüfung wurde mit verschiedenen Arten von Cruciferen, ausserdem für einige Arten wie *Arabis flagellosa* zu verschiedenen Jahreszeiten wiederholt, doch habe ich in allen Fällen keinen Wurzelpilz gefunden, analog dem Versuch von STAHL. Die Wasserpflanzen wie Nymphaeaceen, *Ludwigia ovalis*, *Trapa natans* und *Limnanthemum nymphoides* var. *japonica* besitzen kein Myzel in den Wurzeln, obgleich bei den Landkräutern der Oenotheraceen und Gentianaceen die Mykorrhiza nicht fehlt; so sind die Blütenpflanzen allgemein im Besitz von Mykorrhiza als eine Eigenschaft der Pflanzenfamilien, trotzdem einige Arten derselben Familie das Merkmal, die Mykorrhiza zu bilden, zuweilen verlieren, weswegen sie nur biologisch Wasserpflanzen sind. Solche obenerwähnte Exemplare werden nicht selten in der Natur zum Vorschein gebracht. Viele Pflanzen sind am Ufer öfters nicht mykotroph, dagegen führen selbst feuchte Pflanzen wie *Ranunculus ternatus* immer die endophytische Mykorrhiza.

Die Mykorrhiza von halbparasitischen Pflanzen wird bei Rhinanthaceen früher als mykorrhizafrei von STAHL angegeben, doch habe ich sowohl an *Thesium chinense* wie *Melampyrum japonicum* die endophytische Mykorrhiza klar festgestellt.

Wir haben nicht viel davon gehört, dass die bakteriotrophen Pflanzen, welche zu *Myrica*, *Elaeagnus*, Leguminosen und *Ardisia* gehören, auch gleichzeitig mykotroph leben. Der Mykorrhizapilz möchte dabei wahrscheinlich für die Wirtspflanzen dadurch nützlich sein, dass er vornehmlich die aufgenommenen organischen Substanzen von aussen heterotrophisch assimiliert, indem der Pilz die Rolle, Luftstickstoff zu binden, den Knöllchenbakterien überlässt (s. Fig. 3).

Unter den Monokotylen, findet man keine Mykorrhiza an Cyperaceen, worauf STAHL aufmerksam machte, und ferner kommt der Wurzelpilz an drei Familien, Araceen, Commelinaceen und Juncaceen, welche in näherer systematischer Stellung stehen, nicht vor. Unter ihren verwandten Familien ragen nur Gramineen und Palmen durch das symbiotische Verhältnis mit dem Wurzelpilz hervor, als Ausnahmefall. Die Hälfte von 22 geprüften Familien, welche zu den höheren Klassen der Monokotylen gehört, sind ausnahmslos mykotroph.

Unter 148 geprüften höheren Pflanzenfamilien, ausser den 15 mykorrhizafreien Kräutern, 11 Wasserpflanzen und 3 oder 5 ektotrophischen Bäumen, habe ich bei allen Fällen gleich die endotrophe Mykorrhiza festgestellt. Man soll insgesamt die Landpflanzen als



mykotroph bezeichnen, da die endotrophen Mykorrhizapflanzen in der Tat etwa 82 Proz. von diesen geprüften Pflanzenfamilien einnehmen

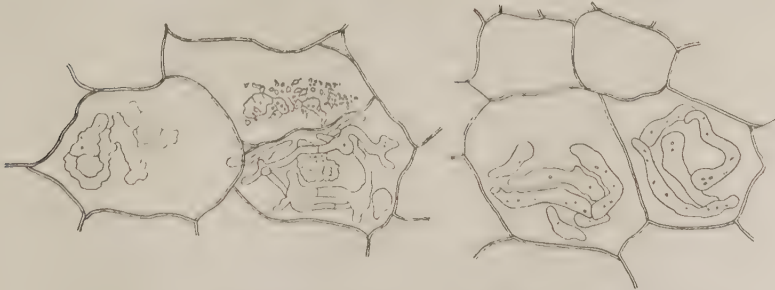


Fig. 3. Rechts lebende Myzelien in den Wurzelzellen von *Ardisia crispa* am 22. Juni, links auslösende von *Albizzia Julibrissin* am 23. Juni. Vergr. 620-fach.

und die nicht mykotrophen Land- und Wasserpflanzen nur 17,6 Proz. bleiben.

### Die Standorte für Mykorrhizabildung

Da meine Beobachtung der Mykorrhiza, wie schon oben erwähnt, nur auf einen engeren Raum wie Garten, Grasebene und Wald begrenzt worden war, lagen also keine merklichen Umstände für die Standortfaktoren der Wirtspflanzen mit Ausnahme des Wasserlebens vor. Der Humusboden in dem Wald und Forst, worin der grösste Teil der höheren Pilze ernährt wird, wird zum ausgezeichneten Standort für Mykorrhizabildung, und es ist ganz natürlich, zu solcher Anschauung bezüglich der Pilzvereinigung mit der Wurzel zu kommen. Die Arbeit von der Baummykorrhiza durch FRANK lenkte bei vielen Forschern die Aufmerksamkeit auf humusreichen Wald; auch wurde die Mykorrhiza wieder an Heide- und Moor-Pflanzen gefunden. Danach kann man im allgemeinen über die Mykorrhiza von der Ansicht sein, dass die Wurzelpilze am häufigsten im Humusboden auftreten und fast auf die Hymenomyceten, die als gewöhnlichste Humusbewohner wohl bekannt sind, sich beschränken.

Eine Untersuchung über die Verbreitung von Mykorrhiza wurde bei den subtropischen Pflanzen aus den geographisch etwas entfernten Koralleninseln und auf den Grenzbezirken, insbesondere humusarmen Standorten wie Meeresküste, Hochgebirge und Vulkan angestellt, und

damit habe ich ermittelt, ob nicht nur die systematische Stellung der Wirtspflanzen, sondern auch die verschiedenen Verhältnisse, welche die Umweltfaktoren der Mykorrhizabildung beeinflussen, wirklich seien. Gleichzeitig habe ich auch meine Arbeit darüber ausgedehnt zu erkennen, welchen Einfluss die Mykorrhiza auf den Lebensprozess, vor allem die Ernährung der Pflanzen hat.

### 1. Mykorrhizapflanzen in den subtropischen Ryukyu-Inseln

(26°10'–26°50' N., 127°40'–128°10'0.)

Das Vorkommen des Mykorrhizapilzes in der tropischen Zone bemerkte JANSE<sup>(1)</sup> früher in der javanischen Flora. Ich habe 46 Arten von 32 Familien, die in Ryukyu von der Gebirgsgegend bis zu der Meeresküste sich ausbreiten, auf die Mykorrhiza hin untersucht. Das Ergebnis ist, wie folgt:

<i>Angiopteris evecta</i> HOFFM.	Endophyt	pH 5.50	16. Juli
<i>Alsophila formosana</i> BAK.	„	5.50	„
<i>Alsophila pustulosa</i> CHRIST	„	5.50	„
<i>Adiantum flabellulatum</i> L.	„	5.95	„
<i>Blechnum orientale</i> L.	„	5.50	„
<i>Nephrolepis cordifolia</i> PR.	„	6.10	„
<i>Cycas revoluta</i> THUNB.	„	5.95	„
<i>Pinus luchuensis</i> MAYR	Ektophyt	6.33	17. Juli
<i>Casuarina equisetifolia</i> FORST.	Endophyt	6.68	13. Juli
<i>Ficus retusa</i> L. var. <i>nitida</i> MIQ.	„	6.94	17. Juli
<i>Drosera Loureiri</i> HOOK. et ARN.	„	5.95	16. Juli
<i>Bryophyllum calycinum</i> SALISB.	„	6.10	„
<i>Sedum Makinoi</i> MAXIM.	„	7.56	14. Juli
<i>Acacia confusa</i> MERR.	„	6.68	13. Juli
<i>Erythrina indica</i> LAM.	„	6.94	16. Juli
<i>Bischofia japonica</i> BLUME	„	6.70	19. Juli
<i>Hibiscus tiliaceus</i> L.	„	6.68	13. Juli
<i>Garcinia spicata</i> HOOK.	„	6.94	16. Juli
<i>Carica Papaya</i> L.	„	6.94	„
<i>Bruguiera gymnorrhiza</i> LAM.	Myzel fehlt	6.65	13. Juli
<i>Terminalia Catappa</i> L.	Endophyt	6.70	19. Juli
<i>Psidium Guayava</i> L.	„	6.33	17. Juli
<i>Melastoma candidum</i> DON.	„	5.95	16. Juli
<i>Sideroxylon ferrugineum</i> HOOK. et ARN.	„	6.94	„
<i>Ipomoea biloba</i> FORSK.	„	6.68	13. Juli
<i>Tournefortia argentea</i> L.	„	7.28	18. Juli

(1) JANSE, J. M., Les endophytes radicaux etc. Ann. Jard. Bot. Buitenzorg. 1896.

<i>Vitex trifolia</i> L. var. <i>ovata</i> MAK.	Endophyt	pH 6.25	14. Juli
<i>Psychotria serpens</i> L.	„	5.95	16. Juli
<i>Scaevola Koenigii</i> VAHL	„	6.25	14. Juli
<i>Crepis lanceolata</i> MAK. var. <i>platyphylla</i> MAK.	„	5.95	16. Juli
<i>Pandanus tectorius</i> SOL. var. <i>liukiuensis</i> WARB.	„	6.68	13. Juli
<i>Andropogon aciculatus</i> RETZ.	„	7.08	14. Juli
<i>Ischaemum antheophoroides</i> MIQ.	„	6.25	15. Juli
<i>Ischaemum muticum</i> L.	„	7.30	18. Juli
<i>Panicum neurodes</i> SCHLT.	„	5.70	16. Juli
<i>Panicum repens</i> L.	„	5.85	15. Juli
<i>Saccharum officinarum</i> L.	„	6.62	14. Juli
<i>Spinifex squarrosus</i> L.	„	7.28	18. Juli
<i>Thuarea sarmentosa</i> PERS.	„	7.56	14. Juli
<i>Zoysia tenuifolia</i> WILLD.	„	6.25	15. Juli
<i>Cyperus rotundus</i> L.	Myzel fehlt	7.30	18. Juli
<i>Didymosperma Engleri</i> WARB.	Endophyt	6.33	17. Juli
<i>Livistona chinensis</i> R. BR.	„	6.94	16. Juli
<i>Ananas sativus</i> SCHULT.	„	6.65	„
<i>Dianella nemorosa</i> LAM.	„	6.62	15. Juli
<i>Musa sapientum</i> L. var. <i>liukiuensis</i> MATSUM.	„	6.70	16. Juli

Alle subtropischen Pflanzen besaßen den Endophyt in dünnen Wurzeln auf dieselbe Weise wie die meiner Gegend, und sein Vorkommen findet an den Küstenpflanzen der kleinen Koralleninseln, von der Hauptinsel fern, statt. Die Wasserstoffionenkonzentration in der Grundlage des Korallenriffs betrug pH 6,5–7,5. An der Küste dieser abgelegenen Inseln herrscht *Scaevola Koenigii* vor, indem sie eine eigentliche grosse Assoziation bildet; dort mischen sich *Pandanus tectorius* var. *liukiuensis* und *Cycas revoluta* bei. Dazwischen treten *Vitex trifolia* var. *ovata*, *Tournefortia argentea*, *Ipomaea biloba*, *Thuarea sarmentosa*, *Ischaemum antheophoroides* und *Zoysia tenuifolia* auf; sie alle sind mykotroph.

Etwa 10 Arten unter den genannten 46 sind Zuchtbäume, welche auf anderen tropischen Gegenden entstanden sind. In der Gebirgsgegend wachsen nicht bloss *Alsophila*, sondern auch viele andere tropische Farne gedeihen; an solchem humusreichen Standort ist die Wasserstoffionenkonzentration nicht von pH 5,5 abgefallen. Die bis zur Meeresküste vortretenden Arten, z.B. *Cycas revoluta*, *Scaevola Koenigii*, *Pandanus tectorius* var. *liukiuensis*, *Ipomaea biloba*, *Sedum Makinoi*, *Vitex trifolia* var. *ovata*, *Crepis lanceolata* var. *platyphylla*, *Ischaemum antheophoroides*, *I. muticum*, *Spinifex squarrosus*, *Thuarea sarmentosa*, *Zoysia tenuifolia* waren alle mykotrophe Pflanzen mit Ausnahme z.B. von *Bruguiera gymnorrhiza*, die im Meerwasser stehen,

und *Cyperus rotundus*. Wohin ich auch immer in Ryukyu kam, Gebirgsgegend, Meeresküste und abgelegene Koralleninseln, waren fast alle Pflanzen von dem Pilzsymbiont bewohnt, wenn sie auf dem Land gut angepasst sind.

## 2. Die Mykorrhizaverbreitung an der Meeresküste

Da in einem Bezirke in der Nähe der Meeresküste der besondere Standort liegt, sind die sogenannten halophytischen Pflanzen, die sich solcher Umwelt anpassen, nicht zu viel an Pflanzenarten. Je näher man dem Strand kommt, desto mehr vermindert die Art sich; schliesslich sind die Pflanzen auf der Sandküste, einige Meter von dem Ufer entfernt, nur auf besondere Arten beschränkt, und ihre Verbreitung ist auch sehr schwach. Die sandige Küste, wo die Bäume nicht gut wachsen, ist humusfrei. Wir finden keinen Humus auf dem Boden, sogar nicht in der Erde. Solche Meeresküste ist zuträglich für die Entwicklung der echten Pilze; demzufolge wird leicht vermutet, dass viele Halophyten mindestens mykorrhizafrei sind. Nach STAHL sind sämtliche Halophyten mykorrhizafrei, aber MÖLLER<sup>(1)</sup> gab in seiner Untersuchung an, dass er bei Kiefern am humusfreien gelben Sand die Ektomykorrhiza massenhaft gefunden hat.

Die halophytischen Pflanzen (27 Arten von 17 Familien) wurden für meine Untersuchung aus der Meeresküste von Ouda, 20 km südwestlich von Kumamoto entfernt, und Fukiagenohama, der berühmten Sandküste im südlichen Kyusyu, besorgt. Das Ergebnis ist, wie folgt, zusammengefasst.

<i>Pinus Thunbergii</i> PARL.	Ektophyt	pH 6.42	6. Juli
<i>Polygonum Reynoutria</i> MAK.	Myzel fehlt	6.78	„
<i>Atriplex tatarica</i> L.	„	7.17	„
<i>Salsola Soda</i> L.	„	6.75	„
<i>Tetragonia expansa</i> AIT.	„	6.75	„
<i>Raphiolepis umbellata</i> MAK.	Endophyt	6.42	„
<i>Canavalia lineata</i> DC.	„	6.06	„
<i>Lathyrus maritimus</i> BIGEL.	„	6.06	„
<i>Evonymus Tanakae</i> MAXIM.	„	6.06	„
<i>Hibiscus tiliaceus</i> L. var. <i>Hamabo</i> MAXIM.	„	6.60	„
<i>Eurya emarginata</i> MAK.	„	7.17	„
<i>Elaeagnus umbellata</i> THUNB.	„	6.78	11. Juli
<i>Cnidium japonicum</i> MIQ.	„	6.42	6. Juli

(1) MÖLLER, A., Untersuchungen über ein- und zweijährige Kiefern im märkischen Sandboden. Zeitschr. f. Forst- u. Jagdwes., 35, 1903.

<i>Phellopterus littoralis</i> BETH.	Endophyt	pH 7.10	11. Juli
<i>Lysimachia mauritiana</i> LAM.	„	7.17	6. Juli
<i>Calystegia Soldanella</i> R. BR.	„	7.17	„
<i>Vitex trifolia</i> L. var. <i>ovata</i> MAK.	„	6.75	„
<i>Aster spathulifolius</i> MAXIM.	„	6.50	11. Sept.
<i>Lactuca repens</i> BENTH.	„	7.10	11. Juli
<i>Ligularia Tussilaginea</i> MAK.	„	6.42	6. Juli
<i>Sonchus uliginosus</i> BIEB.	„	6.42	„
<i>Wedelia prostrata</i> HEMSL.	„	7.10	11. Juli
<i>Ischaemum anthephoroides</i> MIQ.	„	7.10	„
<i>Ischaemum muticum</i> L.	„	7.11	„
<i>Bulbostylis barbata</i> KUNTH	Myzel fehlt	6.74	„
<i>Carex macrocephala</i> WILLD.	„	6.98	„
<i>Fimbristylis sericea</i> R. BR.	„	6.78	„

Wie schon erwähnt, sind die Mykorrhizen so weit in den Landpflanzen verbreitet, dass sie bis zu den Halophyten auf dem Korallenriff kleiner abgelegener Inseln nachgewiesen werden. Die halophytischen Pflanzen lassen sich mit einigen Ausnahmen auch von Pilzsymbionten in den Wurzeln bewohnen. Alle Arten, die zu den Polygonaceen, Chenopodiaceen, Aizoaceen und Cyperaceen gehören, sind mykorrhizafrei, wie bei gewöhnlichen Landpflanzen. Selbst bei den auf dem humusfreien Sandboden nächst dem Ufer gewachsenen *Vitex trifolia* var. *ovata*, *Ischaemum anthephoroides*, *Wedelia prostrata*, *Lactuca repens* und *Calystegia soldanella*, wird die endotrophe Mykorrhiza klar festgestellt. Die Verbreitung der Mykorrhiza hängt nicht immer von der Humusmenge in dem Boden ab nach der Ansicht von MÖLLER. Mit anderen Worten wird die Eigenschaft, die Mykorrhiza zu führen, noch nicht unter dem so begrenzten Standort verloren, dass die Umweltfaktoren für die Verbreitung und Struktur der Pflanzen stark verändernd einwirken. Alle Halophyten sind auch im allgemeinen mykotroph, ausser einigen Arten in gewisser systematischen Stellung, und diese Tatsache zeigt daraufhin, dass der Standort an der Meeresküste die Mykorrhizabildung gar nicht beeinflusst.

### 3. Die Mykorrhiza der Alpenpflanzen

Über die Mykorrhiza der Alpenpflanzen ist die Angabe von HESSELMAN<sup>(1)</sup> und die Tatsache der Wurzelverpilzung an den Alpenpflanzen, z. B. *Dryas octopetala*, die von ihm festgestellt worden war, gleichfalls

(1) HESSELMAN, H., Om mykorrhizabildningar hos arktika växter. Bihang k. Svenska Vet. Ak. Handl., 26, 1900.



auf das arktische Gebiet auszudehnen. Doch wurde anderseits neuerdings durch MC DOUGALL<sup>(1)</sup> darüber berichtet, dass die Mykorrhizapflanzen in dem zentralen Gebiet der Rocky Mountains sehr gering verbreitet seien. Wir haben noch einen weiteren Versuch nach der Pilzverbreitung an den Alpenpflanzen nötig, um daran zu entscheiden, ob der Standort auf dem Hochgebirge wirklich einen Einfluss auf die Wurzelverpilzung ausübt. Somit habe ich die Verbreitung der Mykorrhiza auf dem Komagatake 2956 m über Meer in der Provinz Shinano geprüft. Der Komagatake ist ein wohlbekanntes Gebirge in Japan mit reicher Alpenflora. Die Pflanzenarten, die zur Untersuchung angewandt wurden, habe ich auf 27 Familien erweitert.

<i>Dryopteris phegopteris</i> C. CHR.	Endophyt	pH 4.92	2750m	2. Aug.
<i>Pinus pumila</i> REGEL	"	4.92	"	"
<i>Betula Ermanni</i> CHAM. et SCHL.				
var. <i>communis</i> KOIDZ.	"	4.92	"	"
<i>Polygonum alpinum</i> ALL. var.				
japonicum MAXIM.	Myzel fehlt	4.94	2850	1. Aug.
<i>Stellaria florida</i> FISCH. var.				
angustifolia MAXIM.	"	5.48	2900	"
<i>Anemone narcissiflora</i> L.	Endophyt	5.10	2850	"
<i>Cardamine resedifolia</i> L.	Myzel fehlt	5.10	"	"
<i>Parnassia alpicola</i> MAK.	Endophyt	4.92	2750	2. Aug.
<i>Geum calthaeifolium</i> SM. var.				
dilatatum TORR. et GRAY	"	5.48	2850	1. Aug.
<i>Geum pentapetala</i> MAK.	"	4.94	"	"
<i>Geranium yezoense</i> FR. et SAV.				
var. <i>nipponicum</i> NAKAI	"	4.92	2750	2. Aug.
<i>Empetrum nigrum</i> L.	"	5.48	2900	1. Aug.
<i>Viola biflora</i> L.	"	4.94	2850	"
<i>Angelica multisecta</i> MAXIM.	"	4.94	"	"
<i>Cornus canadensis</i> L.	"	4.20	2650	2. Aug.
<i>Diapensia lapponica</i> L.	"	5.48	2900	1. Aug.
<i>Shortia soldanelloides</i> MAK. var.				
genuina MAK. f. <i>alpina</i> MAK.	"	5.10	2850	"
<i>Monotropa Hypopitys</i> L. var.				
japonica FR. et SAV.	"	4.32	2300	2. Aug.
<i>Monotropa uniflora</i> L.	"	4.32	2300	"
<i>Arctous alpina</i> NIEDZ.	"	5.48	2850	1. Aug.
<i>Cassiope lycopodioides</i> DON.	"	5.42	2900	"
<i>Phyllodoce nipponica</i> MAK.	"	5.48	2900m	1. Aug.
<i>Pieris nana</i> MAK.	"	5.48	"	"
<i>Vaccinium Vitis-idaea</i> L.	"	5.48	"	"

(1) MC DOUGALL, W. B., and JACOBS, M. C., Tree mycorrhizas from the central Rocky Mountain region. Am. Jour. Bot., **14**, 1927.

<i>Trientalis europaea</i> L.	Endophyt	pH 4.20	2650	2. Aug.
<i>Gentiana algida</i> PALL. var. <i>sibirica</i> KUSN.	"	5.10	2900	1. Aug.
<i>Melampyrum japonicum</i> NAKAI.	"	5.42	1000	2. Aug.
var. <i>genuinum</i> NAKAI.	"	4.94	2850	"
<i>Veronica nipponica</i> MAK.	"	5.10	2900	1. Aug.
<i>Campanula dasyantha</i> BIEB.	"	4.92	2750	2. Aug.
<i>Anaphalis margaritacea</i> BENTH. et HOOK.	"	5.10	2850	1. Aug.
<i>Arnica unalaschensis</i> LESS.	"	5.05	2900	"
<i>Agrostis flaccida</i> HACK.	"	5.10	"	"
<i>Deschampsia flexuosa</i> TRIN.	"	5.10	2850	"
<i>Festuca ovina</i> L.	"	5.10	2900	"
<i>Hierochloe alpina</i> ROEM. et SCH.	"	4.94	2850	"
<i>Carex Doenitzii</i> BOECK.	Myzel fehlt	5.48	"	"
<i>Carex pyrenaica</i> WAHL.	"	5.48	2900	"
<i>Carex stenantha</i> FR. et SAV.	"	5.10	"	"
<i>Luzula campestris</i> D. C.	"	5.10	"	"
var. <i>sudetica</i> ČELAK.	"	4.86	2700	2. Aug.
<i>Lilium Hansonii</i> BAK.	Endophyt	5.42	2900	1. Aug.
<i>Lloydia alpina</i> SALISB.	"	4.25	2750	2. Aug.
<i>Veratrum album</i> L. var. <i>lobelianum</i> BAK. f. <i>japonica</i> BAK.	"	4.86	2700	"
<i>Orchis aristata</i> FISCH.	"			

In dem Hochgebirge in unserer gemässigten Zone wird der Standort durch reichlichen Humus am Abhang bis zu der Nähe des Gipfels unterstützt, und die Wasserstoffionenkonzentration beträgt beinahe pH 4,0; aber im Felsgebiet des Gipfels, das verhältnismässig humusarm ist, zeigt diese Konzentration etwa pH 5,0. Wegen des besonderen Standortes ist die Pflanzenverbreitung am Gipfel sehr schwach und kleine Assoziationsfragmente können nur unter den Felsen erblickt werden. Wir fanden die typischen Endomykorrhizen an vielen Alpenpflanzen auf 2900 m in der Nähe des Gipfels verbreitet, wie *Geum calthaeifolium* var. *dilatatum*, *G. pentapetala*, *Diapensia japonica*, *Shortia soldanelloides* var. *genuina*, *Gentiana algida* var. *sibirica*, *Campanula dasyantha*, *Arnica unalaschensis*, *Agrostis flaccida*, *Deschampsia flexuosa*, *Hierochloe alpina*, und *Lloydia alpina* (Fig. 4).

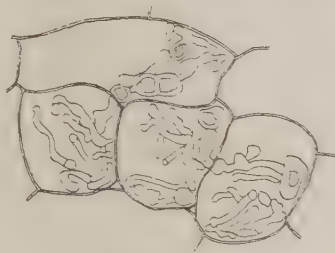


Fig. 4. Zerfallende Myzelien in den Wurzelzellen von *Lloydia alpina* am 2. Aug. Vergr. 620-fach.

Kurz gesagt, sind die Alpenpflanzen auch im allgemeinen mykotroph, ohne dass verschiedene Verhältnisse aus dem alpinischen Standort an der Wurzelverpilzung beteiligt sind. Ich habe den Wurzelpilz an *Polygonum alpinum* var. *japonica*, *Stellaria florida* var. *angustifolia*, *Cardamine resedifolia*, *Carex Doenitzii*, *C. pyrenaica* und *C. stenantha* nicht gesehen, und die ektotrophe Mykorrhiza an *Pinus pumila*, *Betula Ermanni* var. *communis* gefunden; allein das ist uns nichts neues. Unter den Alpenpflanzen gibt es viele zu den Ericaceen gehörende Arten, an denen ein Wurzelpilz bloss in besonderen epidermalen Zellen der dünnen Wurzeln wohnt. Diese Myzelfäden sind viel dünner als das gewöhnliche endotrophe Myzel, vielmehr etwas näher in dem ektotrophen an Aussehen; diese Struktur wurde in der Wurzel von *Diapensia* und *Shortia*, welche mit Ericaceen in näherer Verwandtschaft stehen, nachgewiesen. Der Befund der Endomykorrhiza an einer halbparasitischen Pflanze, *Melampyrum japonicum* var. *genuinum*, ist auch ohne Interesse, gleichfalls derselbe von *Thesium chinense*.

#### 4. Verbreitung der Mykorrhiza an den Kraterpflanzen

Wir finden einen anderen besonderen Standort der Pflanzen in dieser Gegend in der Umgebung der Krater, die mit vulkanischer Asche ausgefüllt sind, und in den Solfataren. Was bedeuten diese Verhältnisse für die Mykorrhizabildung? Unter Annahme der Angabe von JANSE über die Verbreitung von Mykorrhiza im tropischen Java, zeigt FABER<sup>(1)</sup> daran, dass die Kraterpflanzen, welche die besondere Assoziation auf dem stickstoffarmen vulkanischen Boden gebildet haben, in vielen Fällen mykotroph oder bakteriotroph sind. Alle von ihm geprüften Solfataren-Pflanzen führten auf jeden Fall den Wurzelsymbiont und eine Hälfte davon gehörte zu den Ericaceen; überdies wurden *Ficus*, *Melastoma*, *Symplocos*, *Elaeocarpus* als Mykorrhizapflanzen aufgezählt. Er behauptete aus obiger Tatsache, dass die mykotrophe und bakteriotrophe Symbiose eine biologisch auffallende Eigenschaft der Solfataren-Pflanzen sei.

35 km östlich von Kumamoto liegt der berühmte Vulkan Aso (1592 m)<sup>(2)</sup>. Sieben Kegelberge erheben sich in der grossen Caldera (Durchmesser: ca. 23 km Südnorden, 16 km Ostwesten) kreuzweise

(1) FABER, FR. Untersuchung über die Physiologie der javanischen Solfataren-Pflanzen. Flora **18-19**, 1925.

(2) WOLFF, F. v., Der Vulkanismus. **77**. Bd, S. 124, Stuttgart 1923.

aufsteigend auf 1000 m Höhe vom Atrio, von denen setzt nur der Nakadate jetzt noch eine lebhaftige Tätigkeit fort. Die Nordostseite desselben Kraters ist in 2 km Länge von einer 150 m hohen Umwallung umstellt, und an der ganz eingestürzten Westseite steigt dieser Zentralkegel mit einem Gefälle von etwa 20 Grad ab.

<i>Salix Sieboldiana</i> BL.	Ektophyt	pH 5.10	15. Aug.
<i>Alnus firma</i> SIEB. et ZUCC.	"	4.95	"
<i>Polygonum Reynoutria</i> MAK.	Myzel fehlt	4.92	"
<i>Hydrangea paniculata</i> SIEB.	Endophyt	4.95	"
<i>Lespedeza cyrtobotrya</i> MIQ.	"	5.12	"
<i>Viola Sieboldi</i> MAXIM.	"	4.64	"
<i>Aralia cordata</i> THUNB.	"	5.14	"
<i>Cnidium longiradiatum</i> YABE	"	4.64	"
<i>Rhododendron kiusianum</i> MAXIM.	"	4.95	"
<i>Gentiana scabra</i> BUNGE.			
var. <i>Buergeri</i> MAXIM.	"	4.12	"
<i>Solidago Virga-aurea</i> L.	"	4.95	"
- <i>Arundinella anomala</i> STEUD.	"	4.95	"
<i>Calamagrostis autumnalis</i>	"	4.92	"
<i>Miscanthus Matsumurae</i> HACK.	"	4.92	"
<i>Miscanthus sinensis</i> ANDERS.	"	4.95	"
<i>Carex blepharicarpa</i> FRANCH.	"	4.92	"
<i>Maianthemum Convallaria</i> WIGG. et ROTH.	"	5.14	"

Ungefähr 1 km von dem Krater entfernt, worauf immer Ausbrüche niedergehen, ist der Boden mit einigen Metern dicker Vulkanasche bedeckt. Die einzige Kraterpflanze *Polygonum Reynoutria* ist dem Krater am nächsten; sie tritt bis zu beinahe 200 m vom Krater vor. Das Assoziationsfragment findet sich zerstreut auf der Asche, sogar auch an der Umwallung, und ein Fragment zeigt zuweilen 6 m Durchm. Nächst *Polygonum* tritt das *Carex*-Fragment 500 m vom Krater auf. Die Wasserstoffionenkonzentration des vulkanischen Bodens in dieser Gegend zeigt pH 4,8-5,3. Trotzdem die Regenmenge etwa 3000 mm pro Jahre ist, wird der Aschenboden von den Pflanzen nicht überwuchert. Wegen der schwachen Wasserkapazität ist der Boden übermässig trocken, also entsteht Humus dort fast nicht und die Wurzeln von *Polygonum* und *Carex* sind in solcher Umwelt vollständig mykorrhiza-frei.

Ich habe einige Gräserarten von vulkanischer Asche, welche aus 150 m vom Krater entnommen, gesät und nur mit Leitungswasser kultiviert, indem sterilisierte und nicht sterilisierte Ackererde als Kontrollen angewandt wurden. Die Entwicklung der Gräser am nährstoff-

armen Aschenboden ging bei allen Versuchen im Vergleich mit anderen Kontrollen immer nicht gut vor sich. Bei jungen Gräsern auf nicht sterilisiertem Boden fand die Verpilzung schon nach drei Wochen von der Keimung statt, obwohl dieselbe an geröstetem Boden in der Blütezeit noch nicht infiziert waren, wogegen am Aschenboden der Mykorrhizapilz nach zwölf Wochen erst festgestellt wurde. Die Verbreitung der Wurzelpilze nämlich ist bis zu solchem Standort weit gelungen; allerdings sind sie sehr schwach.

Von dem Krater noch bis zu 1 km nach Westen entfernt findet man die *Rhododendron kiusianum*-*Alnus firma* Assoziation; dazwischen tritt eine grosse Menge von *Salix Sieboldiana*, *Hydrangea paniculata*, *Aralia cordata*, *Cnidium longeradiatum*, *Solidago Virga-aurea*, *Arundinella anomala*, *Calamagrostis autumnalis*, *Miscanthus Matsumurae*, *M. sinensis* und *Maianthemum Convallaria* auf, ausser bereits genannten Arten, und der vulkanische Boden ist mit dieser Vegetation ziemlich dicht bedeckt. Nur *Salix*- und *Alnus*-Arten tragen die ektotrophen Pilzmäntel auf dünnen Wurzeln; andere führen aber im allgemeinen den Endophyt in den Wurzeln, trotz des sehr humusarmen Aschenbodens.

Von demselben Krater 5 km nach Südwesten ist ein Explosionskrater und verschiedene Solfataren-Pflanzen sind bis zu den Explosionslöchern vorgetreten; *Fimbristylis ferruginea* tritt am nächsten zum Schwefeldampf auf, dann folgen *Miscanthus sinensis* und *Polygonum Reynoutria*. Diese Pflanzen treten so nahe an die Ausstosslöcher vor, dass die ganze Pflanze manchmal mit auskristallisiertem Schwefel bedeckt erscheint. Die Wasserstoffionenkonzentration in der Solfatara, worauf die genannten Pflanzen wachsen, betrug pH 3,34 und in der näheren Umgebung pH 4,42. Ich habe an *Fimbristylis* und *Polygonum* kein Myzel nachgewiesen, dagegen an *Miscanthus* deutlich, und die meisten Solfataren-Pflanzen waren auch mykotroph. Die Solfatara beteiligt sich nicht an der Bildung der Mykorrhiza.

<i>Alnus firma</i> SIEB. et ZUCC.	Ektophyt	pH 4.42	15. Aug.
<i>Polygonum Reynoutria</i> MAK.	Myzel fehlt	3.34	„
<i>Hydrangea paniculata</i> SIEB.	Endophyt	4.06	„
<i>Eurya japonica</i> THUNB.			
var. <i>Thunbergii</i> THW.	„	3.82	„
<i>Halorrhagis micrantha</i> R. BR.	„	4.06	„
<i>Cnidium longeradiatum</i> YABE	„	4.42	„
<i>Rhododendron kiusianum</i> MAXIM.	„	4.06	„
<i>Arundinella anomala</i> STEUD.	„	3.34	„



<i>Miscanthus Matsumurae</i> HACK.	Endophyt	pH 4.06	15. Aug.
<i>Miscanthus sinensis</i> ANDERS.	„	3.34	„
<i>Fimbristylis ferruginea</i> VAHL.	„	3.51	„
<i>Maianthemum Convallaria</i> WIGG. et ROTH.	„	4.06	„

FABER vermutete, dass die Wurzelpilze den Luftstickstoff möglicherweise assimilieren, wie bei den Knöllchenbakterien, und die Kraterpflanzen auf dem vulkanischen Boden den Stickstoffbedarf damit ergänzen können. Selbst bei Ericaceen ist dieses Problem aber heute noch fraglich geblieben, geschweige denn bei anderen Mykorrhizen. Wenn auch wir die Fähigkeit den Luftstickstoff zu fixieren den Wurzelpilzen zuerkennen würden, es wäre nicht immer ein Merkmal, das nur auf die Kraterpflanzen besonders zu beschränken wäre. Nach unserer Beobachtung am näheren Rand des tätigen Kraters, wo andere Pflanzen nicht mehr wachsen können, gedeihen nur *Polygonum* und *Carex* von vulkanischer Asche überschüttet noch gut; an ihnen kann man die Mykorrhiza gar nicht feststellen; und *Fimbristylis* und *Polygonum* auf der Solfatara sind ebenfalls mykorrhizafrei. Ich möchte hier noch hinzufügen, dass die Solfataren-Pflanzen, die von FABER auf 2500 m Höhe geprüft wurden, allerdings in tropischer Gegend stehen; also war eine Hälfte von ihnen die charakteristischen Arten, die zu den Ericaceen gehören. Die Kraterpflanzen auf unserem Kegelgebirge Aso wurden in der Höhe von 1100–1200 m gesammelt, und die Lage der Solfatara liegt nur auf 800 m Höhe. Manche Arten, die sich dort ausbreiten, sehen wir in dieser Gegend im Gebirgsland gewöhnlich; insbesondere ist *Polygonum Reynoutria* von der Gebirgsgegend bis zur Meeresküste sehr weit verbreitet.

Die Mykorrhiza zu bilden ist eine auffallende Eigenschaft, welche nur an den Landpflanzen erblickt wird. Unter den Dikotylen, die zahlreiche Arten umfassen, gibt es eine Ausnahme, wo die Mykorrhiza nicht geführt wird, bei nur einer Gruppe und näher stehenden Familien in der systematischen Stellung; und auch einige die ektotrophe Mykorrhiza tragenden Familien finden sich in einer Stellung zusammen. Ferner beherbergt eine andere Gruppe Wurzelpilze nur in den grossen epidermalen Zellen der Wurzel. Diese Tatsachen erzählen wohl, dass eine Beziehung der Mykorrhiza zu den Landpflanzen wahrscheinlich phylogenetisch schon von alter Zeit her stammt. Wenn auch die biologischen Einflüsse durch die geographischen Verhältnisse und besonderen Standorte bei den Wirtspflanzen so stark sichtbar werden, bleibt eine symbiotische Vereinigung mit dem Wurzelpilz an einer

Gruppe in systematischer Stellung gar nicht veränderlich. Der einzige Umweltfaktor, welcher die Mykorrhizabildung direkt beeinflusst, unabhängig von der systematischen Stellung, ist nur das Wasser.

### Die Grasmykorrhizen

Ich habe bereits über das weitere Vorkommen der Wurzelpilze bei höheren Landpflanzen an einigen Exemplaren jeder Familie berichtet, ohne die Mykorrhizasymbiose nur auf bestimmte Blütenpflanzen zu beschränken; und wir haben auch erfahren, dass trotz eines Grenz-Standortes in der Natur der Einfluss auf solche Eigenschaft, dass die Landpflanzen die Mykorrhiza für sich behalten, nicht so stark ist. Jedoch kommt noch ein einziger Fall hier in Frage, nämlich der Standort im Wasser. Wir können die Wurzelverpilzung an *Oenothera biennis* sicher nachweisen, doch nicht an *Ludwigia ovalis* und *Trapa natans*, die zu denselben Oenotheraceen gehören, und an *Limnanthemum nymphoides* der Gentianaceen. Weil diese Pflanzen sich dem Wasserleben anpassen, ist die allgemeine Eigenschaft für ihre Familien als Mykorrhizapflanzen verloren. STAHL berichtete schon früher, dass die Mykorrhiza an den eigentlichen Wasser- und Uferpflanzen gänzlich fehlt. Aber die Heide und das Moor sind anderseits als Standort für typische Mykorrhizapflanzen bekannt. Um meine Kenntnis über die Mykorrhiza zu erweitern, machte ich dann den Versuch, wie weit der Wurzelpilz in jeder geprüften Familie vorkommt und welcher Standort die Wurzelverpilzung an den verschiedenen Arten derselben Familie beeinflusst. Es fiel mir ein, dass zu diesem Zweck die Gräser eine treffende Familie sind. Die Gramineen sind eine grosse Pflanzenfamilie, welche 4000 Arten umfasst und überall auf der Erde verbreitet sind. Einige davon sind die durch Samen vermehrten einjährigen Gräser, die anderen, die durch Rhizomen verbreiteten mehrjährigen, gewisse kleine wachsen nur um einige Centimeter, während einige Baumgräser in der tropischen Zone gelangen zur Entwicklung auf 30 m Höhe.<sup>(1)</sup> In der Tat liefern die Gräser die verschiedenen Arten von Landpflanzen auf allen Standorten in der Natur für unsere Untersuchung.

Die Mykorrhiza bei Gramineen ist bisher nicht viel bekannt, ausser der an *Molinia* und japanischen Bambuseen. Viele Grasarten würden aus verschiedenen Standorten wie Gebirgsland, Grasebene, Acker,

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(1) Wie *Dendrocalamus giganteus* in Malay oder *D. latiflorus* in Formosa.

Reisfeld, Ufer und Meeresküste in dieser Gegend gesammelt; so erreichte die Summe von Arten und Varietäten 82 von 52 Gattungen. Das kurz zusammengefasste Ergebnis über die Gramineen ist das folgende:

## Gebirgsland

<i>Calamagrostis arundinacea</i> ROTH. var. <i>sciuroides</i> HACK.	mehrfährig	Endophyt	pH 5.67	28. Mai
<i>Calamagrostis autumnalis</i> KOIDZ.	„	„	4.92	8. Okt.
<i>Festuca ovina</i> L.	„	„	5.10	31. Aug.
<i>Lophatherum gracile</i> BRONGN. var. <i>elatum</i> HACK.	„	„	5.62	1. Nov.
<i>Miscanthus Matsumurae</i> HACK.	„	„	4.95	8. Okt.
<i>Miscanthus sinensis</i> ANDERS.	„	„	4.95	„
<i>Sasa albo-marginata</i> MAK. et SHIBATA	„	„	5.73	„
<i>Shibataea Kumasasa</i> MAK.	„	„	5.48	1. Nov.

## Grasebene

<i>Agropyrum ciliare</i> FRANCH.	zweijährig	Endophyt	pH 5.57	13. Mai
<i>Agropyrum semicostatum</i> NEES.	„	„	5.57	„
<i>Agrostis tenuiflora</i> STEUD.	„	„	5.57	29. Apr.
<i>Andropogon brevifolius</i> SW.	einjährig	„	5.37	15. Juni
<i>Andropogon Nardus</i> L. var. <i>Goeringii</i> HACK.	mehrfährig	„	5.45	2. Okt.
<i>Andropogon serratus</i> THUNB. var. <i>genuina</i> HACK.	„	„	5.57	5. Nov.
<i>Arthraxon ciliaris</i> BEAUV.	einjährig	„	5.67	2. Nov.
<i>Arundinella anomala</i> STEUD.	mehrfährig	„	5.57	11. Okt.
<i>Avena fatua</i> L.	zweijährig	„	5.39	25. Apr.
<i>Briza maxima</i> L.	„	„	5.45	„
<i>Briza minor</i> L.	„	„	5.64	12. Mai
<i>Bromus pauciflorus</i> HACK.	mehrfährig	„	5.67	15. Juni
<i>Coix Lacryma-Jobi</i> L.	„	„	5.27	24. Okt.
<i>Cynodon Dactylon</i> PERS.	„	„	5.57	27. Okt.
<i>Eleusine indica</i> GAERTN.	einjährig	„	5.49	2. Nov.
<i>Eragrostis ferruginea</i> BEAUV.	mehrfährig	„	5.44	23. Okt.
<i>Eragrostis japonica</i> TRIN.	einjährig	„	5.54	1. Nov.
<i>Eragrostis major</i> HOST.	zweijährig	„	5.71	5. Juli
<i>Eragrostis pilosa</i> BEAUV.	einjährig	„	5.64	30. Mai
<i>Eriochloa villosa</i> KUNTH.	„	„	5.45	25. Okt.
<i>Festuca parvigluma</i> STEUD.	mehrfährig	„	5.67	7. Apr.
<i>Imperata arundinacea</i> CYR.	„	„	6.94	25. Okt.
<i>Muehlenbergia japonica</i> STEUD.	„	„	5.22	„
<i>Opismenus Burmanni</i> BEAUV.	„	„	5.67	30. Okt.
<i>Panicum indicum</i> L.	einjährig	„	5.66	22. Sept.
<i>Panicum sanguinale</i> L. var. <i>ciliare</i> DOELL.	„	„	5.62	29. Okt.

<i>Panicum violascens</i> KUNTH.	einjährig	Endophyt	pH 5.47	28. Okt.
<i>Paspalum Thunbergii</i> KUNTH.	mehrfährig	„	5.57	25. Okt.
<i>Pennisetum purpurascens</i> MAK.	„	„	5.57	22. Okt.
<i>Poa acroleuca</i> STEUD.	zweijährig	„	5.66	8. Apr.
<i>Poa acroleuca</i> STEUD. var. <i>submoniliformis</i> MAK.	mehrfährig	„	5.66	29. Apr.
<i>Poa annua</i> L.	zweijährig	„	5.62	7. Apr.
<i>Poa palustris</i> L. var. <i>strictula</i> HACK.	mehrfährig	„	5.67	26. Apr.
<i>Poa sphondylodes</i> TRIN.	zweijährig	„	5.68	28. Mai
<i>Pogonatherum saccharoideum</i> BEAUV.	mehrfährig	„	5.62	9. Sept.
<i>Pollinia imberbis</i> NEES. <i>genuina</i> HACK.	einjährig	„	5.50	27. Okt.
<i>Setaria glauca</i> BEAUV.	„	„	5.48	5. Aug.
<i>Setaria viridis</i> BEAUV.	„	„	5.49	16. Juni
<i>Setaria viridis</i> BEAUV. var. <i>purpurascens</i> MAXIM.	„	„	5.49	5. Juli
<i>Spodiopogon cotulifer</i> HACK.	mehrfährig	„	5.07	31. Okt.
<i>Sporobolus elongatus</i> R. BR.	„	„	5.50	25. Okt.
<i>Themeda Forskali</i> HACK. var. <i>japonica</i> HACK.	„	„	5.60	1. Nov.
<i>Trisetum flavescens</i> BEAUV. var. <i>papillosum</i> HACK.	„	„	5.45	5. Mai
<i>Zoysia pungens</i> WILLD. var. <i>japonica</i> HACK.	„	„	5.57	1. Nov.
<i>Zoysia tenuifolia</i> WILLD.	„	„	5.47	17. Mai

## Acker

<i>Andropogon Sorghum</i> BROT. var. <i>vulgaris</i> HACK.	einjährig	Endophyt	pH 5.27	3. Nov.
<i>Avena sativa</i> L.	zweijährig	„	5.32	30. Apr.
<i>Hordeum sativum</i> JESS. var. <i>hexastichon</i> HACK.	„	„	5.02	29. Apr.
<i>Panicum Crus Galli</i> L. var. <i>frumentaceum</i> HOOK. f.	einjährig	„	5.39	30. Okt.
<i>Panicum miliaceum</i> L.	„	„	5.39	25. Okt.
<i>Setaria italica</i> BEAUV.	„	„	5.44	28. Aug.
<i>Triticum sativum</i> LAM. var. <i>vulgare</i> HACK.	zweijährig	„	5.31	29. Apr.
<i>Zea Mays</i> L.	einjährig	„	5.40	28. Aug.

## Ufer und Reisfeld

<i>Alopecurus fulvus</i> L.	zweijährig	Endophyt	pH 5.31	3. Mai
<i>Beckmannia erucaeformis</i> HOST.	„	Myzel fehlt	5.25	28. Apr.
<i>Glyceria acutiflora</i> TORR.	„	„	5.10	5. Mai
<i>Glyceria tonglensis</i> CLARKE	„	„	5.40	12. Mai
<i>Isachne australis</i> R. BR.	mehrfährig	„	5.10	29. Okt.
<i>Leersia oryzoides</i> SW. var. <i>japonica</i> HACK.	„	„	5.18	6. Okt.

<i>Leptochloa chinensis</i> NEES.	einjährig	Myzel fehlt	pH 5.40	25. Okt.
<i>Oryza sativa</i> L.	"	"	5.25	24. Okt.
<i>Panicum acronathum</i> STEUD.	"	Endophyt	5.33	10. Aug.
<i>Panicum Crus Galli</i> L. var. <i>submuticum</i> MEY.	"	"	5.33	24. Okt.
<i>Phalaris arundinacea</i> L. var. <i>genuina</i> HACK.	mehrfjährig	"	5.40	12. Mai
<i>Phalaris arundinacea</i> L. var. <i>picta</i> L.	"	"	5.38	1. Nov.
<i>Phragmites longivalvis</i> STEUD.	"	Myzel fehlt	4.95	28. Okt.
<i>Rottboellia compressa</i> L. f. var. <i>japonica</i> HACK.	"	"	5.10	29. Okt.
<i>Zizania latifolium</i> GRISEB.	"	"	4.95	1. Nov.

### Meeresküste

<i>Arundo Donax</i> L.	Mehrfjährig	Endophyt	pH 6.28	1. Nov.
<i>Ischaemum anthephoroides</i> MIQ.	"	"	7.17	7. Nov.
<i>Ischaemum muticum</i> L.	"	"	7.17	"
<i>Miscanthus japonicus</i> ANDERS.	"	"	6.82	"
<i>Polypogon monspeliensis</i> DESF.	einjährig	"	7.17	"
<i>Rottboellia latifolia</i> STEUD.	mehrfjährig	"	6.75	"

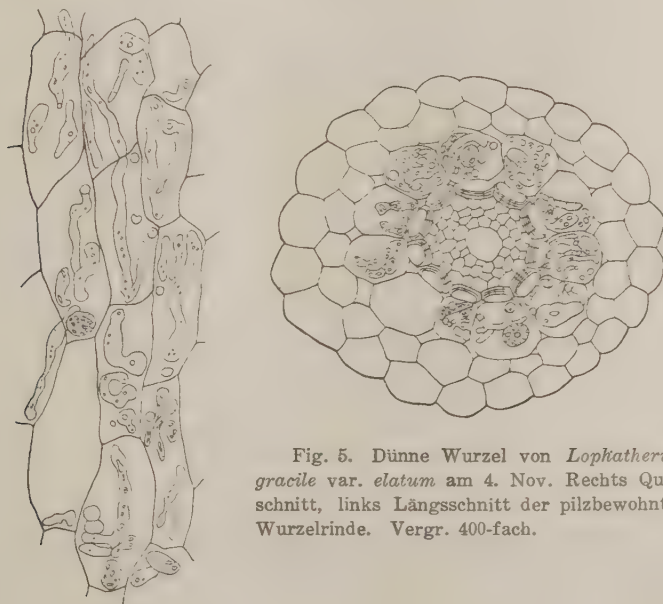


Fig. 5. Dünne Wurzel von *Lophatherum gracile* var. *elatum* am 4. Nov. Rechts Querschnitt, links Längsschnitt der pilzbewohnten Wurzelrinde. Vergr. 400-fach.



Ohne Beteiligung an allen Standorten kann ich nach meinen obigen Resultaten sämtliche Gramineen als mykorrhizatragende Pflanzen angeben, und zwar dass der Wurzelsymbiont an den Gräsern gern im Wasser lebe, wurde mit nur einer einzigen Ausnahme, nicht gefunden. Bei den am Ufer wachsenden Gräsern wie z. B. *Alopecurus fulvus*, *Panicum acroanthum*, *P. Crus Galli* var. *submuticum*, *Phalaris arundinacea* var. *genuina*, *Polypogon monspeliensis* findet man stets den Endophyt in den dünnen Wurzeln. Die im Acker keimenden, jungen Pflanzen von *Alopecurus fulvus*, *Panicum acroanthum* und *P. Crus Galli* sind Mitte Mai ebenfalls unfehlbar durch den Wurzelpilz infiziert; jedoch an den im Wasser gewachsenen Pflanzen wird kein Myzel nachgewiesen. Wenn *Oryza sativa* und *Rottboellia compressa* var. *japonica*, die dem Wasserleben gut angepasst sind, auf dem Acker oder an der Wegseite keimen, werden dagegen die jungen Pflanzen immer vom Wurzelpilz bewohnt. Im November des vorigen Jahres hatte ich festgestellt, dass an *Phragmites longivalvis*, welche im Wasser wächst, der Myzelfaden in den Wurzeln gänzlich fehlt. Danach wurde ein Stück Rhizom derselben Pflanze auf den Acker verpflanzt, worauf ihre Entwicklung natürlich stark gehemmt wurde im Verhältnis zu der bei dem Wasserleben, aber die Pilzmyzelien kamen im Mai schon in allen neuen Wurzeln vor. Also finden die Wasserpflanzen nicht von Natur aus keinen Gefallen an der Symbiose mit dem Wurzelpilz. Wenn die verpilzten jungen Gräser wie *Pennisetum purpurascens*, *Panicum acroanthum*, *P. Crus Galli* in Wasser verpflanzt werden, können wir nach drei Monaten (in der Blütezeit dieser Pflanzen) den Pilzfaden in der Wurzelrinde noch teilweise erblicken. Wenn wir die Gräser Samen auf dem sterilisierten Boden säen, findet man aber die Pilzinfektion an jungen Pflanzen, die im gerösteten oder dampfsterilisierten Boden, nur mit Leitungswasser ernährt werden, gar nicht statt, während die Gräser in dem nicht sterilisierten Boden unter denselben Bedingungen in vier oder fünf Wochen nach der Keimung verpilzt sind. Werden die gut entwickelten genannten Gräser, denen die Wurzeln völlig abgeschnitten werden, mit PRIANISCHNIKOWScher Lösung ernährt, werden sie nicht von dem Wurzelpilz ergriffen, obgleich die adventiven Wurzeln nach drei Wochen von neuem genügend gewachsen sind. Wir gelangen auch zu demselben Ergebnis mit Teichwasser anstatt des Leitungswassers.

Der Fadenpilz wird mit einer grossen Menge Kohlenhydrate aus den Landpflanzen versorgt, und freier Sauerstoff ist für die Stoffzersetzung vor seiner Aufnahme unbedingt nötig; allein der Wassergehalt

des Nährmittels, bei welchem der Pilz zu gedeihen beginnt, ist schon genug mit beinahe nur 10 Proz., in Unterschied zu den Bakterien.<sup>(1)</sup> Der echte Pilz ist durchaus dem Landleben angepasst und sehr schwach dem Wasserleben. Das Leben in der Wurzelrinde der Wasserpflanzen ist wenigstens nicht zweckmässig für die echten Pilze, überdies ist die Pilzflora im Wasser sehr beschränkt. Also möchte ich vielleicht darin recht haben zu sagen, dass der Zufall, dass die höheren Pflanzen im Wasser von den Wurzelpilzen infiziert werden, sehr selten ist.

Wie bereits wiederholt erwähnt, selbst wenn der Standort für die Pflanzen biologisch eine grosse Veränderung hervorruft, hat das im allgemeinen mit der Mykorrhizabildung keinen Zusammenhang. Obwohl ein Einfluss auf das Vorkommen des Pilzsymbionts ausgeübt wird, hat das bei den wasserlebenden Pflanzen nicht den erblichen Grund wie das Verhältnis der systematischen Stellung. Wir bringen ihre eigentliche Natur für die Mykorrhiza durch das Verpflanzen auf das Land möglichst ans Licht; umgekehrt wird dieselbe Eigenschaft, die einmal die Wurzel erworben hat, durch Eintauchen in Wasser nicht verloren.

### Die Infektion und Lebensdauer der Wurzelpilze

Das Stadium der Verpilzung der Mykorrhiza tritt nach BERNARD an den meisten Orchideen schon bei der Keimung auf, und dabei ist die Keimung von der Pilzinfektion abhängig; deshalb ist die Symbiose für die Wirtspflanzen obligatorisch.<sup>(2)</sup>

Säen wir am Anfang April die Gräser Samen wie z. B. *Oryza sativa*, *Panicum acroanthum*, *P. Crus Galli* var. *submuticum*, *P. violascens*, *Setaria viridis* var. *purpurascens*, *Zea Mays*, *Lophatherum gracile* var. *elatum* und *Pennisetum purpurascens*, so keimen sie nach etwa drei Wochen; danach wird der Wurzelpilz noch lange nicht gefunden, ihre Verpilzung findet erst vier oder fünf Wochen nach der Keimung, Mitte Mai statt. Bei *Zea Mays* wird allerdings die Pilzinfektion Ende April bereits an den jungen Pflanzen erregt, welche sich zu 10 cm hoch im Stengel und 15 cm lang in der Wurzel entwickelt. Bei Orchideen mag

(1) LÖHNIS, F., Vorlesungen über landwirtschaftliche Bakteriologie. S. 63, Berlin 1913.

(2) Es ist von BERNARD bekannt, dass *Cattleya*-Arten durch die Zuckerernährung zur Keimung gebracht werden können, ohne Infektion durch den Pilz.

(3) PRAT, H., Étude des mykorrhizes du *Taxus baccata*. Ann. des Sc. Nat. Bot. 8, 1926.

die Pilzinfektion für die Ernährung des Keimlings obligatorisch erforderlich sein, doch ist sie bei den Gramineen von der Keimung nicht abhängig. Der Mykorrhizapilz spielt in der Regel nicht immer eine wichtige Rolle in solcher Richtung für die Wirtspflanzen. Die Pilzinfektion beginnt gewöhnlich vom Ende April in der gemässigten Gegend und erscheint am höchsten im Mai und Juni. Aber das steht mit dem Entwicklungsstadium der Wirtspflanzen nicht in Beziehung. Wenn wir die Samen von *Alopecurus fulvus*, *Avena sativa*, *Hordeum sativum* var. *hexastichon* und *Triticum sativum* var. *vulgare* Mitte November

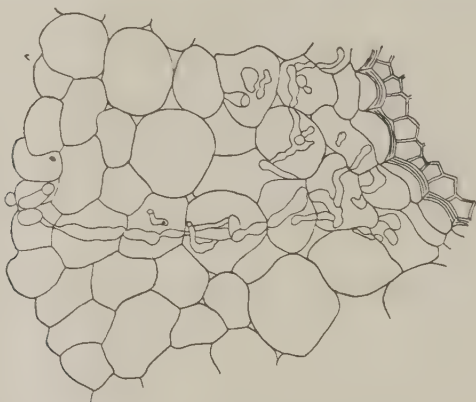


Fig. 6. Pilzinfektion in der Wurzel von *Triticum sativum* var. *vulgare* am 29. Apr. Vergr. 400-fach.

säen, entwickeln die jungen Gräser sich nach einem Monat, z. B. bei *Triticum* 7–8 cm hoch im Stengel, 3–4 cm lang in der Wurzel, aber während des Winters wohnt der Wurzelpilz in der zweijährigen Pflanze nicht, und infiziert erst Ende April, wo bereits junge Ähren gesehen werden (Fig. 6). Ich habe allerdings im November an den jungen Pflanzen von *Lathyrus odoratus*, *Euphorbia Helioscopia*, *Torilis Anthriscus*, *Veronica Tourneforti*, *Agropyrum semicostatum*, *Sisyrinchium Bermudianum*, ausserdem an *Anemone coronaria* und *Narcissus Jonquilla* die endophytische Mykorrhiza auch nachgewiesen. Schliesslich ist noch zu sagen, dass der Wurzelpilz auch zu jener Zeit leicht infiziert, wo sein Wachstum am lebhaftesten fortgeschritten ist; im kältesten Februar habe ich einst die Verpilzung in der Wurzel von *Shibataea Kumasasa* festgestellt (Fig. 7).

Nun ist es eine andere Frage für die Wurzelverpilzung, wo der Pilz in der Wurzelrinde einfällt, um sie zu infizieren. Es ist schon lange bekannt, dass die Knöllchenbakterien bei der Infektion zuerst von den Wurzelhaaren eindringen; ebenso auch beobachtete PRAT neuerdings die ähnliche Verpilzung an dem Endophyt von *Taxus buccata*.<sup>3\*</sup> Wo der Mykorrhizapilz in der Wurzel wohnt, sind im allgemeinen die sehr dünnen Teile von etwa 0,2–0,3 mm Durchm. und er dehnt sich vornehmlich zu der Wachstumszone von der Wurzelhaarzone aus. Ich habe nur in seltenen Fällen den Myzelfaden in den Wurzelhaaren gefunden, z. B.

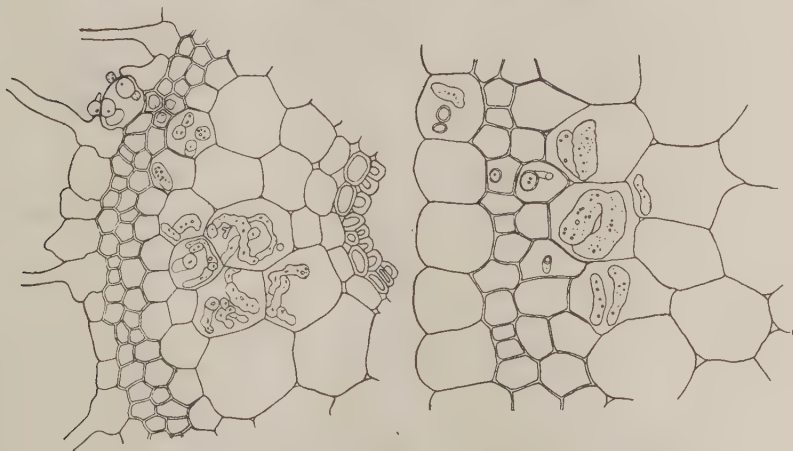


Fig. 7. Pilzinfektion in der Wurzel von *Shibataea Kumasasa*.  
Rechts am 3. Mai, links am 14. Feb. Vergr. 400-fach.

an *Shibataea Kumasasa* (am 13. Februar) (Fig. 7) und *Briza minor* (am 12. Mai), und auch an den Arten von Orchideen ist er manchmal erblickt worden. Der Wurzelpilz wird am gewöhnlichsten unmittelbar von den epidermalen Zellen der dünnen Wurzel infiziert, dann geht er nach und nach innen in die Wurzelrinde durch und schliesslich werden die Rindenzellen eine oder manchmal zwei Schichten um den Zentralzylinder mit den Myzelfäden angefüllt, aber in den epidermalen Zellen und den ihnen nahen Rindenzellen werden die Hyphen gar nicht gesehen. Das lebende Myzel verläuft in den Zellen längsweise, ohne sich zu einem Klumpen zusammen zu wickeln. In der Wurzelrinde, die aus mehreren Zellschichten besteht, von der Wurzelhaarzone entfernt, ist das Vorkommen des Wurzelpilzes sogar nicht nur um den Zentralzylinder,



sondern über die ganze Rinde ausgebreitet (Fig. 8). Die Myzelfäden in so gewachsenen Rindenzellen zerfallen in kleine Stückchen, wobei sie das Aussehen des Myzels verlieren, oder bilden zuweilen einen Klumpen, und ferner bleiben aufgelöste Myzelfäden, welche öfter<sup>s</sup>

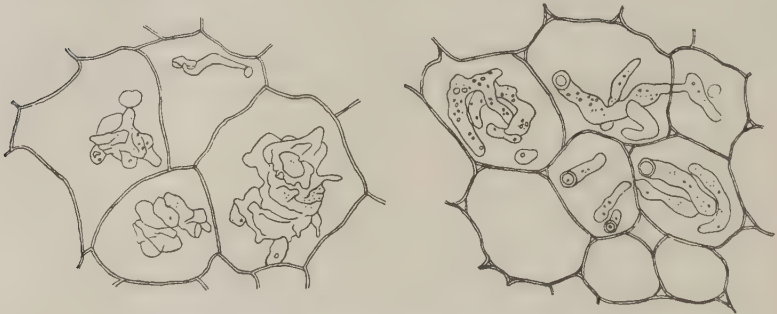


Fig. 8. Rindenzellen mit dem Wurzelpilz von *Zoysia pungens* var. *japonica*. Rechts lebende Myzelien am 2. Mai, links klumpige am 4. Nov. Vergr. 620-fach.

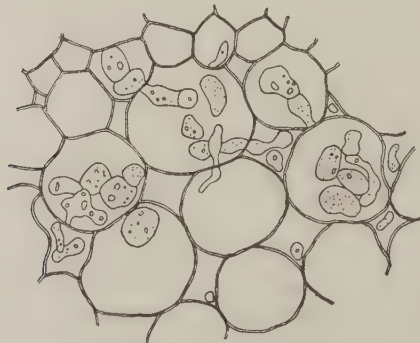


Fig. 9. Gelbliche Masse, von aufgelöstem Myzel kommend, in der Wurzelrinde von *Panicum Crus Galli* var. *genuina*, am 14. Nov. Vergr. 620-fach.

insbesondere um die Fruchtzeit, sich in eine gelbe Masse verwandeln, in den Rindenzellen übrig. Auf jeden Fall verschwinden sie schliesslich nach einer Weile durch die Aufnahme der Wirtspflanzen, aus den Rindenzellen entleert (Fig. 9).



Die Lebensdauer des Mykorrhizapilzes wurde bisher in vielen Fällen für einjährig gehalten. Nach dem Absterben der Wirtspflanzen werden die Rindenzellen der infizierten Wurzel in der Tat im ganzen durch die Aufsaugung des Wirtes leerstehend, doch nach meinem

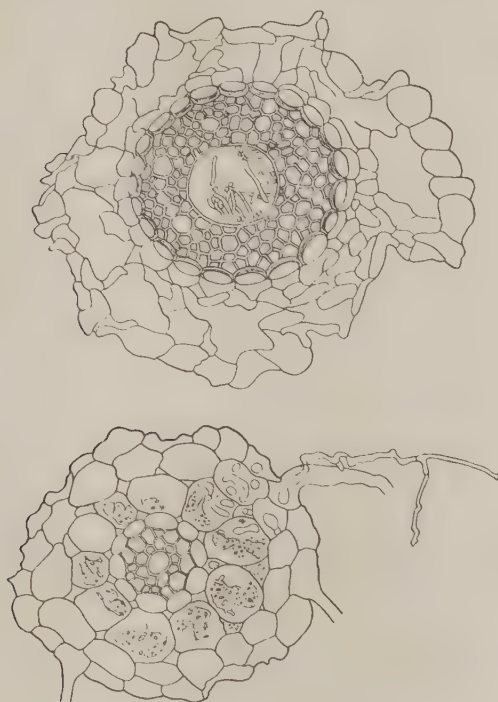


Fig. 10. Myzelien in der abgestorbenen Wurzel von *Panicum acroanthum* am 13. Jan. Rechts lebende Myzelfäden an der Peripherie und aufgelöste in den inneren Rindenzellen. Vergr. 400-fach. Links lebende Myzelien im Gefäss, Wurzelrinde eingestürzt. Vergr. 260-fach.

Versuch, welcher an den dünnen Wurzeln von 0,15–0,3 mm Durchm. bei *Andropogon brevifolius*, *Eragrostis pilosa*, *Oryza sativa*, *Panicum acroanthum* (Fig. 10), *P. Crus Galli* var. *submuticum*, *P. violascens*,

*Setaria italica*, *S. viridis* var. *purpurascens* und *Zea Mays* ausgeführt wurde, geht der Wurzelpilz in der abgestorbenen Wurzel nicht immer gänzlich unter, tritt öfters in dem lebendigen Myzelzustand in äusseren Rindenschichten, selbst zuweilen in der Epidermis auf, obgleich die Myzelfäden in den inneren Rindenzellen aufgelöst sind; sogar fand ich an *Panicum acroanthum* lebende Myzelfäden massenhaft in den Gefässen der abgestorbenen Wurzel, worin ihre Anwesenheit niemals an den lebenden Wirtspflanzen nachgewiesen worden ist. Die Wurzelrinde der mehrjährigen Gräser ist im Winter von gesunden Endophyten bewohnt worden, sogar bei einem immergrünen Zwergbambus, *Shibataea Kumasasa*, habe ich die Myzelfäden in dem Infektionsstadium im kältesten Februar gefunden; sie haben natürlich nicht so lebendiges Aussehen wie die im Mai beobachteten. In der Wachstumsperiode dieser Bambusgräser (im Juli und August), wenn die jungen Sprösslinge wachsen, wird der Mykorrhizapilz in klumpigen oder zerbröckelten Massen nur teilweise in den Rindenzellen, und in der neugewachsenen Wurzel auch nicht zu oft erblickt. Dann aber sind die Rindenzellen im Oktober in der ziemlich dicken Wurzel noch mit dem Myzel angefüllt gewesen. Ferner habe ich über die Lebensdauer des Wurzelpilzes an dem immergrünen Strauch (*Gardenia jasminoides*) und dem laubfallenden (*Evonymus alata* var. *striata*) das ganze Jahr hindurch Beobachtungen angestellt. Der Mykorrhizapilz in den dünnen Wurzeln genannter beiden Pflanzen, wie mit 0,2–0,3 mm Durchm., kommt vom Frühling bis zum Sommer in dem Rindengewebe ziemlich ausgedehnt und mit dem Aussehen des lebenden Myzelfadens vor. Aber vom Ende des Sommers beginnt das Myzel in den Rindenzellen allmählich sich aufzulösen und im Herbst häufig teilweise zu gelblicher Masse sich umzuwandeln, und selbst im kältesten Winter bleibt ein Teil noch immer in dem Myzelzustand in äusserer Rinde übrig, ohne aus den Rindenzellen gänzlich zu verschwinden.

Mit kurzen Worten ist der Mykorrhizapilz nicht immer einjährig; nach dem Absterben der Wirtspflanzen bleibt er teilweise in dem Myzelfaden übrig und überwintert auch in dem Myzelzustand bei den Bäumen und Sträuchern, sogar mehrjährigen Kräutern. Er hat in jedem Fall das Schicksal, verdaut zu werden nach seinem Gedeihen, doch stirbt er nicht immer aus. Der Wurzelpilz wuchert in der Frühlingszeit lebendig am besten und wird zum grossen Teil vom Ende Sommer zum Herbst hin von den Wirtspflanzen aufgelöst und aufgenommen; aber ein Teil des Myzels überwintert in den Zellen.

## Zwei Bautypen der endotropen Mykorrhizen

Die Mykorrhizapilze finden sich immer steril im verpilzten Zustand, also müssen sie zu ihrer Identifizierung zuerst isoliert und überdies durch Synthesenversuch noch festgestellt werden. Es gibt bisher viele verschiedene Fadenpilze, welche als Mykorrhizapilze isoliert wurden; aber dass der Wurzelpilz durch abermaligen Synthesenversuch noch genauer festgestellt wurde, ist nur an einigen Nadelbäumen und Orchideen bekannt. Unter den ektotropen Pilzsymbionten von Kiefern nach MELIN sind die *Boletus*-Arten am häufigsten vertreten, und als nächste Pilzarten zählte er *Amanita*, *Cortinarius*, *Lactarius*, *Russula* und *Tricholoma* auf. Alle sind wohl bekannte, zu den Hymenomyceten gehörenden Humusbewohner. Viele Forscher bemühten sich den Wurzelpilz aus Orchideen zu isolieren, und BERNARD ist zuerst in seinem Synthesenversuche gelungen, wobei er diesen Pilz als zu der *Hypochnus*-Art gehörend annahm. Bald darauf gab BURGEFF ihm den neuen Namen *Orcheomyces*, womit allerdings über seine systematische Stellung keine Klärung erreicht ist. Bezüglich der Mykorrhizapilze ist man schliesslich auf die humusbewohnenden Pilze aufmerksam geworden, so ist das Ziel auf die Ektophyten ins Auge gefasst. Dagegen haben wir für die Endophyten selbst darüber keine genügende Kenntnis, zu welcher Stellung sie systematisch gehören; weil wegen der Schwierigkeit der Isolierung die gewonnenen Pilze in vielen Fällen nicht unumstritten sind, ausser einigen besonderen Wurzelpilzen wie dem Orchideenpilz. Aber die Verbreitung der endotropen Mykorrhiza ist so weit, dass man auf jeden Boden den Mykorrhizapilz auf dem Land konstatieren kann, wenn Pflanzen dort wachsen, ohne nur auf den Humusboden beschränkt zu sein. Ich habe drei *Fusarium*-Arten<sup>(1)</sup>, eine aus *Zoysia pungens* var. *japonica* und *Shibataea Kumasasa*, zwei andere aus Halophyten, *Spinifex squarrosus* und *Canavalia lineata* isoliert; aber diese Pilze sind noch nicht durch den Synthesenversuch festgestellt worden.

Nach meiner Beobachtung an vielen verschiedenen Mykorrhizen, habe ich im ganzen den endotropen in zwei mögliche Abstammungen unterschieden. Der Myzelfaden eines Bautyps ist 5–7  $\mu$  dick und wohnt in der Tiefe bis zur Nähe um den Zentralzylinder in der Wurzelrinde. Das Pilzmyzel in der dünnen Wurzel tritt stets ein, zuweilen an zwei

(1) Ebenso hatte FUCHS den in den meisten Früchten von *Lolium*-Arten anzutreffenden Pilz als ein *Fusarium* bezeichnet. Hedwigia, 51, 1911.

Zellschichten, welche die Endodermis umgeben, auf, allein nicht in den epidermalen Zellen und Wurzelhaaren. Es ist dieser Mykorrhizabildner, welcher die Mykorrhizaerscheinung in der Natur sehr weit beherrscht. Andere, welche  $2-3\mu$  dicke Hyphen besitzen, kommen vornehmlich nur auf die epidermalen Zellen beschränkt vor, und da diese pilzführenden Zellen sich deutlich nicht nur im Inhalt, sondern auch in der Form von den benachbarten Rindenzellen unterscheiden, so werden sie von den gewöhnlichen epidermalen Zellen der Wurzeln leicht unterschieden. Solche eigentümliche Mykorrhiza wird fast nur an den Arten, welche zu den Diapensialen und Ericalen gehören, wie z.B. *Diapensia lapponica*, *Shortia soldanelloides* var. *genuina*, *Pirola japonica*, *Phyllodoce nipponica*, *Rhododendron kiusianum*, *Vaccinium Vitis-idaea* gesehen, und zwar bei *Clethra barbinervis* habe ich ausnahmsweise die gewöhnliche typische Mykorrhiza und auch bei *Empetrum nigrum* den letzterem eigentümlichen Typ erblickt. HASSELBAUM<sup>(1)</sup> bemerkte neuerdings dazu die Ähnlichkeit zwischen beiden Familien von der Seite der Mykorrhiza, die im Jahre 1913 SAMUELSON<sup>(2)</sup> über die Verwandtschaft der Empetraceen zu den Ericaceen beschrieben hatte.

Betrachtet man eine dünne Wurzel, 0,3–0,4 mm Durchm. von *Pirola japonica* (Fig. 11), so sind die epidermalen Zellen vielmehr kleiner in der Form als andere Rindenzellen, stehen ihre Wurzelhaare kapillennähnlich an mehreren Stellen hervor und der Wurzelpilz wohnt darin gar nicht. Aber nach dem Wachstum verändert diese dünne Wurzel sich in der Struktur stark. Wenn ihr Durchmesser zu etwa 0,6 mm sich entwickelt hat, wird der Rand der Wurzel von zwei Fünftel der epidermalen Zellen, welche abnormal eierförmig entwickelt sind, eingenommen und in jeder dieser Zellen umspinnen sehr dünne Pilzfäden den riesigen Zellkern, und öfters kann man die aufgelösten Hyphen von der aufgespeicherten Substanz schwer unterscheiden, während die übrigen epidermalen Zellen, ebenso mit Pilzfäden eingehüllt, unter diese abnormalen Zellen tief eingeklemmt werden; und das Rindengewebe bewahrt nur Stärkekörner auf, ohne das Myzel zu führen. Über die Mykorrhizen der Pirolaceen, die *Monotropa*-Arten in sich fassen, habe ich noch viel zu studieren; meine Arbeit darüber ist im Gange.

(1) HASSELBAUM, G., Cytologische und physiologische Studien zur ericoiden endotrophen Mykorrhiza von *Empetrum nigrum*. Bot. Archiv, **31**, 1931.

(2) SAMUELSON, G., Studien über die Entwicklungsgeschichte der Blüten einiger Bicornes-Typen. Svensk Bot. Tidskrift, **7**, 1913.

Die Endophyten von Orchideen sind gewöhnlich nur  $2-3\mu$  dick, z.B. an *Bletia hyacinthina*, *Calanthe discolor*, *Cymbidium virens*, *Dendrobium nobile*, *Goodyera Schlechtendaliana* und *Liparis nervosa*; selbst ein dicker Myzelfaden wie an *Spiranthes australis* überschreitet nicht  $5\mu$  Dicke. Der Orchideenpilz tritt in den ziemlich dicken Wurzeln,

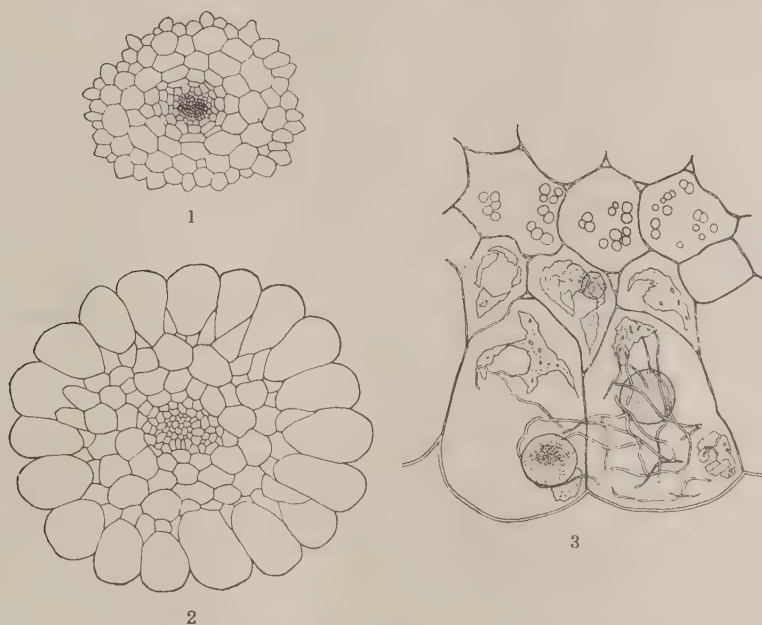


Fig. 11. Querschnitt der Wurzel von *Pirola japonica*, 1. pilzfreie junge Wurzel ca. 0,4mm Durchm., 2. pilzbewohnte erwachsene ca. 0,6mm Durchm. am 7. Juli. Vergr. 110-fach, 3. ein Teil der pilzbewohnten Epidermis; die äusseren zwei Schichten bestehen aus den epidermalen Zellen, in denen nur wenig, aufgelöstes Myzel übrig blieb, am 9. Aug. Vergr. 400-fach.

1-2 mm Durchm., zu Tage und wohnt in der Wurzelrinde bis zu den epidermalen Zellen, häufig sich in den Wurzelhaaren weit ausbreitend; dagegen fehlen den Wurzeln die Myzelfäden in den meisten Fällen in den innersten Rindenteilen. Ich möchte lieber urteilen, dass die Abstammung der speziellen Mykorrhizapilze an Orchideen wahrscheinlich auch vom *Pirola*-Typ gekommen sei.



Die ektotrophe Mykorrhiza bildet in der Nähe der Wurzelpilz den Pilzmantel, nicht nur umspinnt das Myzel die dünnen Wurzeln oberflächlich eng, sondern es verläuft auch öfters im inneren Rindengewebe interzellulär. Der Wurzelpilz an *Pinus Thunbergii*, *Salix Sieboldiana*, *Alnus firma* und *Corylus heterophylla* var. *japonica* betrug etwa 2-3  $\mu$  Dicke. Nach unseren bisher gewonnenen Resultaten ist die Beziehung der Mykorrhiza zu den Wirtspflanzen in der Regel fakultativ mit einigen Ausnahmen, z.B. *Neottia* und *Monotropa*. Wie die ektotrophe Mykorrhiza im humusreichen Boden stets zu finden ist, ist es vielmehr die ältere anfängliche Form der Mykorrhizasymbiose, und davon ist nur ein Schritt zur endotrophen Mykorrhiza des *Pyrola*-Typs. Diese Art der Mykorrhizen ist zweifellos endotroph im Aussehen und so, als ob sie in einem grossen Unterschied zu der ektotrophen Mykorrhiza stände; doch nach der Eigenschaft des Myzelfadens wäre sie eher von derselben Abstammung ursprünglich hergekommen, und die symbiotische Vereinigung wäre so dabei inniger als die ektotrophe geworden, dass die Myzelinfektion die Veränderung bis zur Struktur der Wurzel hervorruft, selten ins obligatorische Verhältnis hineintreibt.

### Die Bedeutung der Wurzelpilze

Verschiedene Vermutungen herrschen bisher für die symbiotische Vereinigung der Mykorrhiza, und in neuerer Zeit berichtete MELIN eine richtige Ansicht bezüglich der ektotrophen Mykorrhiza; aber diese Erklärung behält nur auf einige Pflanzengruppen beschränkt ihre Geltung. Das Zentrum des Mykorrhizaproblems muss auch in der endotrophen Mykorrhiza liegen. Die Versorgung der Kohlenstoffquelle durch den Wurzelpilz spielt als Nährstoff der grünen Pflanzen keine so wichtige Rolle wie bei den heterotrophen. Es ist seit langem eine wohl bekannte Tatsache, dass der freie Luftstickstoff in der Natur durch spezielle Bakterien assimiliert wird und die ungeheure Menge des so gebundenen Stickstoffs von den höheren Pflanzen als Stickstoffquelle gebraucht wird; insbesondere ist die Stickstofffixierung der Aktinomykosen in der Wurzel an *Alnus*- und *Myrica*-Arten experimentell nachgewiesen<sup>(1)</sup>. Also ist es kein Wunder zu denken, dass das Verhältnis

(1) SHIBATA, K., Cytologische Studien über die endotrophen Mykorrhizen. Jabrb. wiss. Bot. 37, 1902. PEKLO, J., Die pflanzlichen Aktinomykosen. Cbl. Bakt. II, 27, 1910. SPRATT, The morphology of the root tubercles of *Alnus* and *Elaeagnus* etc. Annals Bot. 1912.

des Mykorrhizapilzes zu den Wirtspflanzen eine symbiotische Erscheinung ist, wobei der Pilzsymbiont einen Teil der Arbeit, den freien Stickstoff zu binden, auf sich nimmt. Die Untersuchung über die Stickstoffquelle der Wirtspflanzen ist durch viele Forscher wiederholt ausgeführt worden, ob nämlich der Mykorrhizapilz die Fähigkeit, den Luftstickstoff zu fixieren, hätte wie die Knöllchenbakterien; bisher ist diese Frage jedoch noch nicht geklärt.

Die Fähigkeit der *Phoma*-Arten, den Luftstickstoff zu binden, wurde von TERNETZ<sup>(1)</sup>, DUGGAR und DAVIS<sup>(2)</sup> zugegeben; insbesondere fixierte ein Pilz, welcher TERNETZ aus dem Heideboden isoliert hatte, den Luftstickstoff wirksamer als bei *Azotobacter*, und später berichtete sie, dass der Mykorrhizapilz an Ericaceen vielleicht identisch mit der *Phoma*-Art sei. Dieselbe Fähigkeit eines systematisch unbekannten Wurzelpilzes, an *Podocarpus*-Arten die Wurzelknöllchen zu bilden, wurde von NOBBE und HILTNER durch lange Züchtung von *Podocarpus* in völlig stickstofffreiem Quarzsand konstatiert. Diese Ergebnisse führen uns immer mehr zu der Vermutung, dass der Mykorrhizapilz wirklich den Luftstickstoff fixiere. Wenn auch ein bestimmter Grund dazu durch einige Wurzelpilze vorhanden wäre, ihre Stickstofffixierung als einseitige Rolle bei der symbiotischen Vereinigung zu halten, ist die Frage noch problematisch, ob alle Mykorrhizapilze in der Natur so ungeheueren Stickstoff der Luft binden, dass sie damit den Stickstoff zur Entwicklung der Wirtspflanzen genügend besorgen können, ebenso wie man bei bakteriotrophen Pflanzen kennen gelernt hat. Nach MELIN<sup>(3)</sup> sind die ektotrophen Mykorrhizapilze vornehmlich *Boletus* und andere zu den Hymenomyceten gehörende Arten, welche keine Fähigkeit, den Luftstickstoff zu fixieren haben, und die Ermittlungen bei der Kiefernmykorrhiza von MÖLLER<sup>(4)</sup> gelangte auch zu negativem Resultat. BURGEFF und HUBER gaben kein deutliches Resultat für die Bindung des freien Stickstoffes von Orchideenpilzen an, und HASSELBAUM gelangte auch an der *Mortierella*-Art, die aus *Empetrum nigrum* isoliert worden war, zu negativem Resultat. Im Gegensatz dazu berichtete

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(1) TERNETZ, Ch., Über die Assimilation des atmosphärischen Stickstoffes durch Pilze. Jahrb. f. wiss. Bot., **44**, 1907.

(2) DUGGAR, B. M., and DAVIS, A. R., Studies in the physiology of the fungi. Annals of the Missouri Bot. Garden, **3**, 1916.

(3) MELIN, E., Untersuchungen über die Bedeutung der Baummykorrhiza. Jena 1925.

(4) MÖLLER, A., Mykorrhizen und Stickstoffernährung. Ber. Deutsch. Bot. Ges., **24**, 1906.

WOLFF<sup>(1)</sup> von Mykorrhizapilzen von *Neottia* und einigen anderen grünen Orchideen, welche den Luftstickstoff stark fixieren. Die Stickstoff-Assimilation durch den Mykorrhizapilz ist heute als eine höchst problematische Frage übrig geblieben.

Eine weitere Frage ist die der anorganischen Salze; STAHL<sup>(2)</sup> behauptete bezüglich der anorganischen Salze, dass der Mykorrhizapilz für höhere Symbionte ausschliesslich zur Aufnahme der Salze dienlich sei. REXHAUSEN<sup>(3)</sup> berichtete über eine Anhäufung der Kalium- und Phosphorverbindungen in ektotrophen Mykorrhizen. Dagegen stellte MELIN durch die reine Kultur der Mykorrhizapflanzen fest, dass die nicht verpilzte Wurzel auch ebenso gut anorganische Salze als die mit Mykorrhiza aufnimmt.

Andererseits sind einige Beobachtungen über den schädlichen Einfluss von Mykorrhizapilzen bekannt; nach NADSON ruft die übermässige Pilzinfektion bei *Quercus* das Absterben der Wurzel hervor und der Orchideenpilz greift bei seinem übermässigen Gedeihen die Wirtspflanzen heftig an, verursacht sogar öfters ihr Absterben.

Wenn auch die Pflanze im unfruchtbaren Boden durch die Symbiose mit dem Mykorrhizapilz mittelbar vom Luftstickstoff ernährt wird, geschieht es nicht in solcher Menge, um für die Entwicklung einen so auffallenden Einfluss auszuüben, wie bei den bakteriotrophen Pflanzen. Nachdem die Anwesenheit des Wurzelpilzes nachgewiesen worden war, hebe ich die Rhizome von *Muehlenbergia japonica* und *Zoysia pungens* var. *japonica* im November in dem Quarzsandboden mit fein zerriebener Holzkohle eingesetzt und mit PRIANISCHNIKOWScher Lösung, welche der Stickstoffquelle beraubt ist, für einige Monaten dem Kulturversuch unterworfen. Dann haben diese keimenden Gräser im nächsten Frühling für eine Zeit ein kümmerliches Leben, während an der Kontrolle mit PRIANISCHNIKOWScher Nährlösung, alle gedeihen und wachsen und Ähren tragen; also ist nicht daran zu denken, dass der Mykorrhizapilz dabei den Stickstoffmangel des höheren Symbionts möglichst genügend ersetzt. Säen wir einige Gräser wie *Panicum acroanthum* (Fig. 12), *P. Crus Galli* var. *submuticum*, *P. violascens*, *Setaria viridis* var. *purpurascens*, *Lophatherum gracile* var. *elatum*, *Pennisetum purpurascens* (Fig. 13) in Töpfe mit geröstetem und nicht geröstetem

(1) WOLFF, H., Zur Physiologie des Wurzelpilzes von *Neottia Nidus avis* RICH. und einigen grünen Orchideen. Jahrb. f. wiss. Bot. **66**, 1926.

(2) STAHL, E., Der Sinn der Mykorrhizenbildung. Jahrb. f. wiss. Bot. **34**, 1900.

(3) REXHAUSEN, L., Über die Bedeutung der ektotrophen Mykorrhiza für die höheren Pflanzen. Beitr. z. Biol. d. Pflanz., **14**, 1920.

Ackerboden, nur mit Leitungswasser ernährt, so verpilzen alle Gräser in nicht geröstetem Boden einige Wochen nach der Keimung; andere jedoch in geröstetem Boden wurden stets nicht gänzlich infiziert und die Entwicklung der ersteren ist immer etwas besser als die der letzteren. Ich habe ein ähnliches Ergebnis mit dem Kulturversuch in dampfsterilisiertem Ackerboden mit *Setaria italica* erhalten.

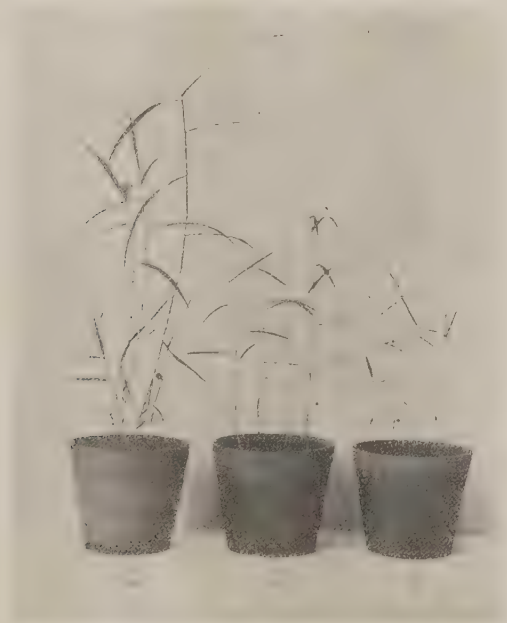


Fig. 12. Kulturversuch mit *Panicum acroanthum* in drei verschiedenen Böden. 1. in Ackerboden, 2. in geröstetem Ackerboden, 3. in vulkanischer Asche.

Es dehnt sich von der Wurzelhaarzone zur Wachstumszone in den dünnen Wurzeln mit etwa 0,2–0,3 mm Durchm. aus, woran der Mykorrhizapilz ein aktives Leben führt. Derselbe Teil der Wurzel, welcher ihre Lebensfunktion genannt werden soll, spielt eine grosse Rolle, um die Nährstoffe aufzunehmen; die aufgenommenen Stoffe werden nach einer Weile in die Gefässbündel durch die Wurzelrinde befördert, gleichfalls ist es der Weg, durch welchen eine Menge von



Assimilaten, welche für die Entwicklung der Wurzel nötig sind, zusammenströmt. Diese Vereinigung mit der höheren Pflanze halten wir darum nicht für eine parasitische Erscheinung, weil die Wurzelpilze hauptsächlich in den den Zentralzylinder umfassenden Rindenzellen an der Wurzelhaarzone wohnen, und nie in die Nähe des Vegetationspunktes einfallen. Wir bemerken in den Rindenzellen häufig Stärkekörner, dagegen in den Myzel führenden Zellen gar nicht. Da die Myzelklumpen über kurz oder lang ein solches Schicksal, aufgelöst und wie Stärkekörner aufgenommen zu werden haben, so bedeutet es keine

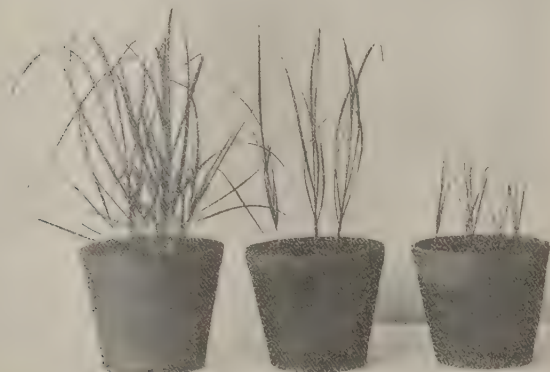


Fig. 13. Kulturversuch mit *Pennisetum purpurascens* in drei verschiedenen Böden. 1. in Ackerboden, 2. in geröstetem Ackerboden, 3. in vulkanischer Asche.

Abweichung davon, dass ein Teil von den Assimilaten für eine Zeitlang in den Rhizomen und Samen aufgenommen und danach aufgenommen werden; aber nur von biologischer Seite liegt darin eine andere, auffallend verschiedene Bedeutung. Der Mykorrhizapilz erhält die Nährstoffe, welche erforderlich für die Entwicklung ist, aus den Assimilaten der Wirtspflanzen und gleichzeitig assimiliert er sehr leicht nur anorganische Salze, sondern auch etwas komplizierte organische Substanzen, welche aus dem Boden aufgenommen werden und die der Wirt schwer assimiliert; und werden sie in den Myzelfäden aufgespeichert,



darunter muss die Stickstoffquelle, die für die Ernährung der höheren Pflanzen in Frage kommt, natürlich enthalten sein und er soll durch die Auflösung der Myzelfäden den Wirtspflanzen nützlich gemacht werden. Die Mykorrhizapilze sind in der Tat stets steril in den Wurzeln der Wirtspflanze, aber bei mehrjährigen Pflanzen bleiben sie in der Wurzerinde überwintert und bei einjährigen kehrt ein Teil von den Myzelfäden auch nach dem Absterben des Wirts in die Erde zurück.

Solche Fähigkeit ist schon experimentell nachgewiesen worden, dass die chlorophyllhaltigen niederen Algen wie *Ulva* im Dunkeln von verschiedenen organischen Substanzen die Stärke assimilieren können; und auch das ist nicht immer unwahrscheinlich, dass die halbparasitischen Pflanzen vom Wirt irgend welche organische Substanzen ausser dem Salzen unmittelbar erhalten, wie andere Parasiten. Die Ernährung von *Neottia* ist ferner obligatorisch vom Endophyt unterhalten worden, im oberirdischen Teil derselben Pflanze fand DRUDE<sup>(1)</sup> das Chlorophyll und erkannte die Fähigkeit der Kohlenstoffassimilation. Überdies wird die ganze Pflanze wie *Monotropa* noch durch den Ektophyt nur von organischen Substanzen ernährt. Also ist es nicht zu verwundern, dass die Ernährung der Mykorrhizapflanzen durch den Pilzsymbiont zum Teil mittelbar von anorganischen Salzen, und sogar auch von organischen Substanzen in der Umgebung erfüllt wird.

Eine symbiotische Vereinigung mit dem Wurzelpilz bei höheren Landpflanzen ist in der Regel nicht obligatorisch wie bei den besonderen Mykorrhizen, doch bei der Wirtspflanze werden nicht dadurch an den Wurzeln schädliche Gebilde verursacht, auch erhält sie keine anderen Schäden, trotzdem diese Erscheinung sehr weit bei den Landpflanzen vorkommt. Wir können diese symbiotische Erscheinung nicht als von auffallender Bedeutung ansehen.

### Zusammenfassung

1. Die Eigenschaft, die Mykorrhiza zu bilden, zeigt sich in der Regel sehr weit an den Landpflanzen, selbst die Pflanzen auf kleinen Koralleninseln, geographisch fern abgelegen, sind in den meisten Fällen auch mykotroph, wenn sie sich gut auf dem Land anpassen; und dies ist mit der systematischen Stellung der Wirtspflanzen eng verbunden.

2. Die Pflanzenarten, welche zu den Polygonalen, Centrospermen und einigen nahe verwandten Familien gehören, sind an allen Stand-

(1) DRUDE, O., Die Biologie von *Monotropa Hypopitys* und *Neottia Nidus avis*. Von der Philos. Fakultät zu Göttingen gekrönte Preisschrift. Göttingen 1873.

orten mykorrhizafrei, und der ektotrophe Mykorrhizapilz kommt auch nur an eng beschränkten Pflanzengruppen vor; aber die weit verbreitete Mykorrhiza ist im allgemeinen endotroph.

3. Wir können die endotrophen Mykorrhizen im ganzen in zwei Bautypen unterscheiden, eine die sehr weit in den Wurzeln der Landpflanzen vorkommt, und eine andere, die fast auf die Diapensialen und Ericalen beschränkt ist. Der letztere Wurzelpilz scheint mir eher in näherer Verwandtschaft zu dem Ektophyt zu stehen.

4. Die verschiedenen Umweltfaktoren für höhere Pflanzen tragen mit Ausnahme des Wassers nichts zur Mykorrhizabildung bei, selbst an solchen Grenz-Standorten wie Meeresküste, Hochgebirge und Vulkan.

5. Bei den im Wasser keimenden Pflanzen tritt stets keine Mykorrhiza auf, obwohl sie auf dem Land leicht die Mykorrhiza bilden, weil nämlich das Wasser kein gutes Infektionsmedium für die Mykorrhizapilze ist. Aber die gebildete symbiotische Vereinigung zerfällt nicht bald durch das Wasserleben.

6. Die Pilzinfektion der Mykorrhiza tritt überall auf dem Land auf, und junge Pflanzen sind schon 4-5 Wochen nach der Keimung verpilzt. Der Wurzelpilz dringt von der Epidermis der dünnen Wurzel im Mai und Juni in der gemässigten Gegend heftig ein, aber die Infektion findet auch im Winter sehr selten statt.

7. Der Mykorrhizapilz stirbt nicht immer nach einem Jahr ab. Die Myzelfäden verschwinden aus der gewachsenen Wurzel durch die Verdauung des höheren Symbionts; jedoch ein Teil überwintert in den meisten Fällen lebendig in dem Myzelfaden, selbst in abgestorbenen Wurzeln der einjährigen Pflanzen.

8. Der Mykorrhizapilz wohnt hauptsächlich in der Wurzelhaarzone der dünnen Wurzel und verletzt nie andere Teile der Wurzel. Der höhere Symbiont gibt einen Teil seiner Assimilate und aufgenommenen Nahrung an die Pilze ab und macht ihnen die anorganischen, sogar auch organischen Stoffe aus dem Boden nutzbar, welche er unmittelbar nicht selbst assimilieren kann; und nach der Entwicklung der Wurzel werden die Wurzelpilze durch den Wirt aufgelöst und gänzlich aufgenommen, ebenso wie ein aufgespeicherter Nährstoff in den Zellen nach dem Gebrauch entleert wird.

FÜNFTE HOCHSCHULE ZU  
KUMAMOTO, JAPAN

# Embryological studies on the different seed-development in reciprocal interspecific crosses of wheat

By

Shunjiro WAKAKUWA

With 2 plates and 7 text-figures

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## Introduction

In reciprocal crosses between species with a different number of chromosomes, seed production by artificial pollination and the germinating ability of the hybrid seeds in many interspecific or intergeneric crosses differ widely according to the direction in which the crosses are made, and they vary markedly in different combinations of the cross. With reference to the interpretation of incompatibility in reciprocal crosses, many authors differ in opinion.

WATKINS (1927, 1932), THOMPSON and CAMERON (1928), and THOMPSON (1930 a, b) reported that there is a marked difference in the success of reciprocal crosses between species of *Triticum* differing in chromosome numbers. And they reached the conclusion that when a species with a high chromosome number is female a greater number of plumped seeds is obtained and their germination is better than when the high chromosome number species is male.

The present author (1930) also made crosses between species of *Triticum* with different or identical chromosome numbers, and obtained the following results in connection with the problem of seed production after cross pollination and the germinating ability of the hybrid seeds.

In *Triticum* the percentage of the seed set and the germination of the hybrid seeds were both good when the parents had the same chromosome numbers. On the other hand, in the cross between species with a different number of chromosomes, the percentage of seed production in reciprocal crosses and that of germination of the hybrid seeds had a contrary relationship to each other. Namely, when a species with a high chromosome number was used as the male, the percentage of seed set was almost normal, but the seeds were wrinkled and germinated badly; while when a species with a lower number of chromosomes was used as the male the percentage of seed set was usually bad, but the seeds obtained were plump and germinated well. These relations were obtained in all reciprocal crosses of pentaploid-, tetraploid- ( $6x \times 2x$ ) and triploid-crosses. Above all, the differences resulting from the direction of the cross were most conspicuous in the reciprocal crosses of tetraploid combination ( $2x \times 6x$ ). In the tetraploid cross, many wrinkled seeds were obtained easily in the direction of the cross  $2x(\varphi) \times 6x(\sigma)$ , while the germination of hybrid seeds always failed. The relationship between the seed set and germination thus showed opposing results. KIHARA and NISHIYAMA (1932) found

the same phenomenon in the reciprocal crosses between diploid and hexaploid oats.

According to KIHARA (1924), the dinkel wheat is allohexaploid, having three different genomes, AA, BB and DD; the emmer group is allotetraploid with two different genomes AA and BB; the diploid einkorn group contains only the AA genomes. Each genome contains one set of 7 chromosomes. As already shown by the work of SAX (1918), the endosperm of *Triticum* is produced by normal triple fusion and its condition is triploid. Accordingly, the genom constitution in the endosperm of dinkel is represented by AAABBBDDD, that of emmer by AAABBB and of einkorn by AAA. The genom constitution of the embryo in the hybrid seed resulting from the reciprocal cross between the species with a different chromosome number is identical, while that of the endosperm differs widely according to whether the high chromosome species is male or female. For instance, the endosperm of seeds resulting from the cross dinkel (AABBDD) ♀ × emmer (AABB) ♂ will have  $3(AB)+2D$  since it is formed from the fusion of 2 polar nuclei (each with ABD) and a male nucleus (with AB). On the other hand, in the reciprocal hybrid, the endosperm will have  $3(AB)+D$  because 2 sets of AB come from the polar nuclei and 1 set of ABD from the male nucleus. In the former case the D genom is diploid and in the latter, haploid. Such differences exist also in the reciprocal crosses of emmer × einkorn and dinkel × einkorn. Namely, when the high chromosome plant is used as female the extra genomes (B or B and D) are diploid, and when used as male, they are haploid.

The germination of the hybrid seeds seems to be closely related with the genom constitution in the endosperm, viz., the germination of the hybrid seeds is much better when the extra genom is diploid. This result is quite in accordance with the work of WATKINS (1927), THOMPSON and CAMERON (1928) and THOMPSON (1930a).

As for the production of seeds in reciprocal pollinations between species with different chromosome numbers, THOMPSON (1930 b) and WATKINS (1932) concluded that successful pollination is obtained when the mother plant has a higher chromosome number. THOMPSON (1930 b) interpreted that the difference in the difficulty of seed production in reciprocal pollination depends on the same principle as in the case of germination. WATKINS (1932) further assumed that failure in crossing is caused by faultiness in germination of the pollen or in the growth of the pollen tube in the style of the mother plant. The normal chromo-



some ratio of pollen tube to style is 1:2. As a rule, if this is changed to 1: more than 2, the pollen tube growth is still generally normal, but if it becomes 1: less than 2, growth is reduced. THOMPSON (1930 b) and WATKINS (1932) reported that their hypotheses may be applied, in general, to many cases in which different degrees of success are found in reciprocal crosses between species which differ in chromosome numbers. However, in the reciprocal crosses between *Triticum* species, the present author (1930) and KIHARA (1932) obtained quite opposite results to THOMPSON and WATKINS' hypotheses. KIHARA and NISHIYAMA (1932) made a very close examination of the development of the bastard embryo and endosperm in *Avena*, and confirmed the fact that THOMPSON and WATKINS' hypotheses for successful pollination are not applicable to *Avena* crosses, in which different degrees of success are found in reciprocal crosses. And they concluded that this difference in seed production in reciprocal crosses is subject to two conditions, —i.e., the pollen tube growth and the activating stimulus of the male nuclei; and that the difference in development of hybrid seeds in reciprocal crosses may be caused by the different strengths of the activating stimulus of the male nuclei on egg and polar nuclei. They considered that their assumption might well be generally applied to many cases where varying success is met with in reciprocal crosses.

In the present work, with regard to the crossing experiments, the purpose was to make it clear that the difference in the seed set and germination is in relation to the direction of crossing, and the author has attempted to demonstrate this fact on the basis of embryological studies in the development of the hybrid embryo and endosperm. The scope of the present work is limited to the problem of wheat, as the subject has been discussed in detail, with extensive examples, by THOMPSON (1930 b), WATKINS (1932), KIHARA and NISHIYAMA (1932), MÜNTZING (1933) and KATAYAMA (1933).

The data of the crossing experiments in this paper are the same as those used in the previous experiments (WAKAKUWA 1930).

## Crossing and germination experiments

### MATERIAL AND METHODS

The following species were used in this work. The genom constitutions depend upon KIHARA's paper (1924).

	n	2n	Genom constitutions
Dinkel group	21	42	AABBDD
<i>T. vulgare</i> 1 <sup>(1)</sup>			
<i>T. vulgare</i> 2			
<i>T. vulgare</i> 3			
<i>T. vulgare</i> 4			
<i>T. spelta</i>			
<i>T. compactum</i>			
Emmer group	14	28	AABB
<i>T. dicoccum</i>			
<i>T. polonicum</i>			
<i>T. durum</i>			
<i>T. dicoccoides</i>			
<i>T. turgidum</i>			
PH. 10 <sup>(2)</sup>			
<i>T. durum</i> × PH. 10			
Einkorn group	7	14	AA
<i>T. monococcum</i>			
<i>T. aegilopoides</i>			

I made crosses in almost all possible combinations of the above mentioned species. The degree of success in pollination is influenced chiefly by the weather, temperature and technical differences, so that the crossings were carried out with great care in the year 1929. All crossings were done in the open field and were quite successful. I usually emasculated spikelets which would open presumably two days later, and then covered such emasculated ears with paraffin paper bags. After two days the spikelets which had been emasculated were dusted with fresh pollens. For the sake of preciseness these crossings were all made in the same year and under the same conditions by the present author. I did not attempt pollination in rainy weather, as fair weather is closely related to the dehiscence of the anthers, which affects the success of pollination. To avoid these defects, the percentage of the seed set was determined by the average percentage of many crosses belonging to the same category (see Table 1 and 2). The percentage of germination of hybrid seeds was determined by the same method as that used in the case of the seed set (see Table 3 and 4).

(1) *T. vulgare* 1 is "*T. vulgare* var. *erythrosperrum* KOERN."; *vulgare* 2 is the cultivated variety "Akakomugi"; *vulgare* 3 is of "Sanjakukomugi"; *vulgare* 4 is the dwarf mutant of "Sanjakukomugi".

(2) PH. 10 is an awnless segregate from the offspring of the pentaploid hybrid (*T. polonicum* × *spelta*).

All hybrid seeds were sown in sterilized soil and were kept in the glass house until the seedlings were big enough to transplant. The number of seedlings was counted before they were transplanted in the open field.

### CROSSING EXPERIMENTS

#### 1. *Crosses between species with the same chromosome number*

The pollination experiments were made between species with the same chromosome number (Table 1).

As shown in Table 1, the percentage of the seed set in the reciprocal crosses between species with the same chromosome number was always the same. The cross compatibility was as good as over 80 per cent in every case. The hybrid seeds were all as plump and healthy in appearance as those of the mother plant itself.

#### 2. *Crosses between species with a different chromosome number*

All possible combinations of crosses between species with different chromosome numbers were undertaken (Table 2).

As clear in Table 2, pollination is always successful when the male plant has a high chromosome number. The details of the cross are given in the following three categories.

##### a) Crosses between hexaploid and tetraploid species

3 wheat species of dinkel and 4 species of emmer were used in this crossing experiment. When dinkel was used as female the average percentage of the seed set was 71.07%. On the other hand, the percentage in the reciprocal cross was 95.28%. The hybrid seeds from  $6x(\text{♀}) \times 4x(\text{♂})$  were plump and of about the same appearance as those of the mother selfed. However, the seeds from  $4x(\text{♀}) \times 6x(\text{♂})$  were wrinkled and unhealthy, and the seeds of the former were slightly smaller than the seeds of the latter.

##### b) Crosses between tetraploid and diploid species

The same results were obtained from triploid combinations. When the species with a high chromosome number was used as the male, the percentage of the seed set was high, but the seeds were wrinkled. When the species with a low chromosome number was used as the

TABLE 1. Seed formations in crosses between species with the same chromosome number in *Tridicum*

Combinations of crosses		Direct crosses			Reciprocal crosses		
♀	♂	No. of flowers pollinated	No. of seeds obtained	%	No. of flowers pollinated	No. of seeds obtained	%
21 × 21							
<i>T. vulgare</i> 1	× <i>spelta</i>	16	15	85.71	10	9	86.84
"	× <i>compactum</i>	16	14		18	16	
"	× <i>vulgare</i> 4	10	7		10	8	
<i>T. spelta</i>	× <i>compactum</i>	14	11	83.33	20	17	90.00
"	× <i>vulgare</i> 4	10	9		10	10	
"	× <i>vulgare</i> 3	9	9		10	10	
<i>T. vulgare</i> 4	× <i>vulgare</i> 2	10	10	100.00	10	10	100.00
14 × 14							
<i>T. polonicum</i>	× <i>dicoccum</i>	12	12	97.92	20	19	95.52
"	× <i>durum</i>	12	12		20	20	
"	× <i>dicoccoides</i>	20	20		16	13	
"	× <i>turgidum</i>	12	12		20	19	
"	× PH. 10	20	19		40	39	
"	× (30 × PH. 10)	20	19		18	18	
<i>T. dicoccum</i>	× <i>durum</i>	12	12	95.45	20	20	94.23
"	× <i>dicoccoides</i>	20	18		12	9	
"	× <i>turgidum</i>	12	12		20	20	
<i>T. durum</i>	× <i>dicoccoides</i>	20	19	98.53	11	10	94.25
"	× <i>turgidum</i>	20	20		20	20	
"	× PH. 10	16	16		38	35	
"	× (30 × PH. 10)	12	12		18	17	
<i>T. dicoccoides</i>	× <i>turgidum</i>	12	12	100.00	20	20	100.00
PH. 10	× (30 × PH. 10)	16	16	100.00	20	18	90.00
7 × 7							
<i>T. aegilopoides</i>	× <i>monococcum</i>	40	32	80.00	29	27	93.10

TABLE 2. Seed formations in crosses between species with a different chromosome number in *Triticum*

Combinations of crosses		Direct crosses		Reciprocal crosses			
♀	♂	No. of flowers pollinated	No. of seeds obtained	%	No. of flowers pollinated	No. of seeds obtained	%
21 × 14							
<i>T. vulgare</i> 1	× <i>polonicum</i>	20	11	71.07	24	19	95.28
"	× <i>dicoccum</i>	14	4		16	16	
"	× <i>durum</i>	16	8		14	14	
"	× <i>turgidum</i>	14	11		20	20	
<i>T. spelta</i>	× <i>polonicum</i>	9	6		15	13	
"	× <i>dicoccum</i>	12	11		36	35	
"	× <i>durum</i>	10	10		15	15	
"	× <i>turgidum</i>	12	12		20	20	
<i>T. compactum</i>	× <i>polonicum</i>	16	13		20	17	
"	× <i>dicoccum</i>	12	9		20	20	
"	× <i>durum</i>	12	11		13	13	
"	× <i>turgidum</i>	12	7		20	20	
14 × 7							
<i>T. polonicum</i>	× <i>aegilopoides</i>	22	19	73.46	20	19	85.04
<i>T. dicoccum</i>	× "	20	20		20	18	
<i>T. durum</i>	× "	20	20		20	19	
<i>T. dicoccoides</i>	× "	8	4		20	19	
<i>T. turgidum</i>	× "	36	36		20	20	
<i>T. dicoccum</i>	× <i>monococcum</i>	40	18		17	11	
<i>T. dicoccoides</i>	× "	16	2		10	2	
21 × 7							
<i>T. vulgare</i> 1	× <i>aegilopoides</i>	20	0	62.31	18	17	93.10
<i>T. spelta</i>	× "	90	63		20	17	
<i>T. compactum</i>	× "	20	18		20	20	



male, the percentage of the seed set was low, but the seeds were almost normal, although the seeds were somewhat smaller than those of the mother.

It was found that the percentage of the seed set is remarkably reduced in the cross *T. dicoccum* (or *dicoccoides*)  $\times$  *monococcum* and its reciprocals. The reason seems to be due to the difference of the flowering time of the parents. The flowering time of einkorn is late as compared with the other group, especially of *T. monococcum*, consequently the technique of pollination between *T. monococcum* and other species is very difficult.

#### c) Crosses between hexaploid and diploid species

The parents of this cross show the greatest difference as to chromosome number. From Table 2 it is clear that pollination is distinctly easier in low chromosome number ( $\varphi$ )  $\times$  high number ( $\sigma$ ). The percentage of the seed set is 93.10, but the seeds are markedly wrinkled and flat. In the reciprocal cross,  $6x(\varphi) \times 2x(\sigma)$ , however, comparatively well developed seeds were obtained though with more difficulty (62.31%).

From the results given above, we may conclude that seeds are usually obtained more easily in low chromosome number ( $\varphi$ )  $\times$  high number ( $\sigma$ ) than in the reciprocal cross.

#### GERMINATION TESTS

All hybrid seeds obtained from the cross between species with the same chromosome numbers showed good germination, over 88 per cent (Table 3).

From Table 3 one can recognize that the germinating power of hybrid seeds in reciprocal crosses between species with the same chromosome number is very good in every case, and that there is no difference in germination between seeds obtained from reciprocal crosses.

On the other hand, the germinating power of the hybrid seeds from the crosses between species with different chromosome numbers differed widely according to the direction in which the crosses were made. Many authors (WATKINS 1927, THOMPSON and CAMERON 1928, THOMPSON 1930 a and WAKAKUWA 1930) have already reported that in *Triticum*, the germination is better in the cross high chromosome number ( $\varphi$ )  $\times$  low number ( $\sigma$ ) than in the reciprocal. The results

TABLE 3. Seed germinations in crosses between species with the same chromosome number in *Triticum*

Combinations of crosses		Direct crosses			Reciprocal crosses		
♀	♂	No. of seeds sown	No. of seeds germinated	%	No. of seeds sown	No. of seeds germinated	%
<b>21×21</b>							
<i>T. vulgare</i> 1	× <i>spelta</i>	15	15	100.00	9	9	96.97
"	× <i>compactum</i>	14	14		16	15	
"	× <i>vulgare</i> 4	7	7		8	8	
<i>T. spelta</i>	× <i>compactum</i>	11	11	100.00	17	16	96.29
"	× <i>vulgare</i> 4	9	9		10	10	
"	× <i>vulgare</i> 8	9	8		10	10	
<i>T. vulgare</i> 4	× <i>vulgare</i> 2	10	10	94.74	10	10	100.00
<b>14×14</b>							
<i>T. polonicum</i>	× <i>dicoccum</i>	12	12	97.87	19	17	95.93
"	× <i>durum</i>	12	12		19	19	
"	× <i>dicoccoides</i>	20	19		9	7	
"	× <i>turgidum</i>	12	12		19	19	
"	× PH. 10	19	18		39	38	
"	× (30×PH. 10)	19	19	97.56	18	18	95.92
<i>T. dicoccum</i>	× <i>durum</i>	12	11		20	20	
"	× <i>dicoccoides</i>	18	18		9	7	
"	× <i>turgidum</i>	11	11	91.04	20	20	97.56
<i>T. durum</i>	× <i>dicoccoides</i>	19	19		10	8	
"	× <i>turgidum</i>	20	19		20	20	
"	× PH. 10	16	12	100.00	35	35	90.09
"	× (30×PH. 10)	12	11		17	17	
<i>T. dicoccoides</i> × <i>turgidum</i>		12	12		20	18	
PH. 10	× (30×PH. 10)	16	16	100.00	18	18	100.00
<b>7×7</b>							
<i>T. aegilopoides</i> × <i>monococcum</i>		32	28	87.50	17	15	88.24

TABLE 4. Seed germinations in crosses between species with a different chromosome number in *Triticum*

Combinations of crosses		Direct crosses			Reciprocal crosses		
♀	♂	No. of seeds sown	No. of seeds germinated	%	No. of seeds sown	No. of seeds germinated	%
21×14							
<i>T. vulgare</i> 1	× <i>polonicum</i>	11	10	98.18	19	12	61.26
"	× <i>dicoccum</i>	4	4		16	15	
"	× <i>durum</i>	8	8		14	4	
"	× <i>turgidum</i>	11	11		20	16	
<i>T. spelta</i>	× <i>polonicum</i>	6	6		13	10	
"	× <i>dicoccum</i>	11	10		35	11	
"	× <i>durum</i>	8	8	93.22	15	15	81.43
"	× <i>turgidum</i>	12	12		20	13	
<i>T. compactum</i>	× <i>polonicum</i>	12	12		17	9	
"	× <i>dicoccum</i>	9	9		20	17	
"	× <i>durum</i>	11	11		13	8	
"	× <i>turgidum</i>	7	7		20	11	
14×7							
<i>T. polonicum</i>	× <i>aegilopoides</i>	18	18	93.22	19	19	81.43
<i>T. dicoccum</i>	× "	20	20		18	14	
<i>T. durum</i>	× "	20	20		19	16	
<i>T. dicoccoides</i>	× "	4	0		19	17	
<i>T. turgidum</i>	× "	36	36		20	20	
<i>T. dicoccum</i>	× <i>monococcum</i>	18	16		11	1	
<i>T. dicoccoides</i>	× "	2	0		2	1	
21×7							
<i>T. vulgare</i> 1	× <i>aegilopoides</i>	0	0	56.79	17	0	0.00
<i>T. spelta</i>	× "	63	29		17	0	
<i>T. compactum</i>	× "	18	17		20	0	

obtained by the author are quite in accord with those of the previous authors (Table 4).

As shown in Table 4, in the cross  $6x \times 4x$ , when  $6x$  species was the female, germination was almost complete (98.18%), but was only 61.26% in the reciprocal.

The difference in germination was slight in the reciprocal crosses between diploid and tetraploid species. Even in this case, there was a difference of 11.74% between them ( $4x(\text{♀}) \times 2x(\text{♂})$  and  $2x(\text{♀}) \times 4x(\text{♂})$ ).

$6x \times 2x$  is the cross in *Triticum* hybridisation showing the greatest difference in chromosome numbers. When the hexaploid species was used as the female the germination was 56.79%, but when it was used as the male, none of the hybrid seeds germinated at all.

#### BRIEF CONSIDERATION ON EXPERIMENTAL RESULTS

The above mentioned crossing and germination experiments may be summarized as follows:

In the cross between species with the same chromosome number, many plump seeds are easily obtained, and their germination is good. The direction of the cross plays no important rôle in this case. On the other hand, in the cross between species with different chromosome numbers the seed set, morphology and germinating power of hybrid seeds differ widely according to the direction of the cross. When the high number species is used as the male, the percentage of the seed set is good, but the seeds are wrinkled and their germination bad. When the low number is used as the male the percentage of the seed set is bad, but the seeds are plump and germinate well. High germination was always associated with plump seeds. These relationships are shown in Table 5.

TABLE 5. Relation between production of seeds, morphology and germination according to the direction of the cross

Combinations of crosses (chromosome number)	Production of seeds	Morphology of seeds	Germination of seeds
Equal number	good	plump	good
Low $\times$ high number	good	wrinkly	bad
High $\times$ low number	bad	plump	good

KIHARA and NISHIYAMA's cases (1932) in *Avena* are identical with those in *Triticum*. In the cross, low chromosome number ( $\varphi$ )  $\times$  high number ( $\sigma$ ), many wrinkled seeds resulted but their germination was bad. The reciprocal cross gave small seeds at a low percentage, but they were plump and germinated well.

As I have already mentioned, it was first advanced by WATKINS (1927) that the difference in germinating power of hybrid seeds resulting from reciprocal crosses was largely due to the chromosome constitution of the endosperm. The genom constitution of hybrid embryos is invariably the same, independent of the direction of the crosses. The endosperms differ, however, in their genom constitution according to the direction of the crosses, when the parents have a different number of chromosomes. The results obtained above (Tables 1-4) are summarized in Table 6<sup>(1)</sup> where the genom constitution of the embryo

TABLE 6. Differences in the seed set and in seed germination according to the differences in genom constitution of the embryo and endosperm.

Combinations of crosses	Chromosome no. in the embryo		Chromosome no. in the endosperm		Percentage (%)	
	No.	Genom constitution	No.	Genom constitution	Seed set	Germination
Dinkel $\times$ dinkel	42	2(ABD)	63	3(ABD)	85.71 $\pm$ 5.40	100.00 $\pm$ 0.00
Reciprocal	42	2(ABD)	63	3(ABD)	86.84 $\pm$ 5.48	96.97 $\pm$ 2.98
Emmer $\times$ emmer	28	2(AB)	42	3(AB)	97.92 $\pm$ 1.46	97.87 $\pm$ 1.49
Reciprocal	23	2(AB)	42	3(AB)	95.52 $\pm$ 1.79	95.93 $\pm$ 1.78
Einkorn $\times$ einkorn	14	2 A	21	3 A	80.00 $\pm$ 6.32	87.50 $\pm$ 5.85
Reciprocal	14	2 A	21	3 A	93.10 $\pm$ 4.71	88.24 $\pm$ 7.81
Dinkel $\times$ emmer	35	2(AB)+D	56	3(AB)+2D	71.07 $\pm$ 3.59	98.18 $\pm$ 4.03
Reciprocal	35	2(AB)+D	49	3(AB)+D	95.28 $\pm$ 4.39	61.26 $\pm$ 4.18
Emmer $\times$ einkorn	21	2 A+B	35	3 A+2B	73.46 $\pm$ 3.47	93.22 $\pm$ 2.31
Reciprocal	21	2 A+B	28	3 A+B	85.04 $\pm$ 3.17	81.48 $\pm$ 3.74
Dinkel $\times$ einkorn	28	2 A+BD	49	3 A+2(BD)	62.31 $\pm$ 4.25	56.79 $\pm$ 5.50
Reciprocal	28	2 A+BD	35	3 A+BD	93.10 $\pm$ 3.33	0.00 $\pm$ 0.00

(1) The percentage of the seed set and germination in this table differ somewhat from those of the previous paper (cf. table 5 WAKAKUWA 1930). Table 6 is calculated from those results, where the crosses are made in both directions. Table 5 of the previous paper also includes the results of crossings where no reciprocal cross was undertaken.



and of the endosperm is given to show its possible relationship to germinating power.

If we compare the germination percentage and the genom constitution of the endosperm, we can draw the following general conclusions:

(1) Germination is best when all genomes present are in triploid condition in the endosperm.

(2) When the extra genom in the endosperm is present in diploid condition germination is better than when it is present in haploid condition.

(3) When there are two kinds of extra genomes in the endosperm (e.g.,  $3A+BD$  and  $3A+2(BD)$ ), germination is weaker than when only one kind of extra genom is included (e.g.,  $3A+B$ ,  $3A+2B$ ,  $3(AB)+D$  and  $3(AB)+2D$ ).

The above mentioned conclusions are reported in the previous paper (WAKAKUWA 1930).

### Embryological studies

Many authors have already made embryological investigations in *Triticum*. Most of them (LÖTSCHER 1905, BRENCLEY 1909, SAX 1918, PERCIVAL 1921, GÜNTHER 1927 and others) have used the pure species. The results of these authors indicate that the principal process of the development of the embryo-sac of *Triticum* is the same as that of other Gramineae. Some authors have made embryological studies on the development of the embryo and endosperm which are formed by selfing of the  $F_1$  and  $F_2$  bastards, but the development of the embryo and endosperm of the hybrid seed, the product of cross pollination, has not been described for wheat so far as I am aware.

SAX (1918) was the first to demonstrate that the normal course of double fertilization takes place in *Triticum*. In the  $F_3$  offspring of pentaploid hybrid, the development of the embryo-sac from the megaspore has been described by WATKINS (1925). KIHARA (1932) has also reported embryological investigations in the  $F_1$  pentaploid hybrids. Their results show that the sterility of pentaploid hybrids is mostly due to the non-fertilization of functioning egg cells and partly to zygotic elimination. According to KIHARA the embryo-sacs of  $F_2$  ovaries from the cross *T. polonicum*  $\times$  *spelta* were almost sound but 57.1% of the sound embryo-sacs remained unfertilized; the remainder (41.1%)

produced embryos but only about 1/3 of them (16.7%) developed into mature grains. The zygotic elimination was, according to KIHARA's estimation, about 24.4% of all embryo-sacs.

I made cytological observations of the development of the hybrid seeds and at the same time observations of the seed formation of pure species were made to check the former. For this purpose three representatives out of three groups of wheat were used. Their chromosome numbers and genom constitutions in embryo and endosperm are given in Table 7.

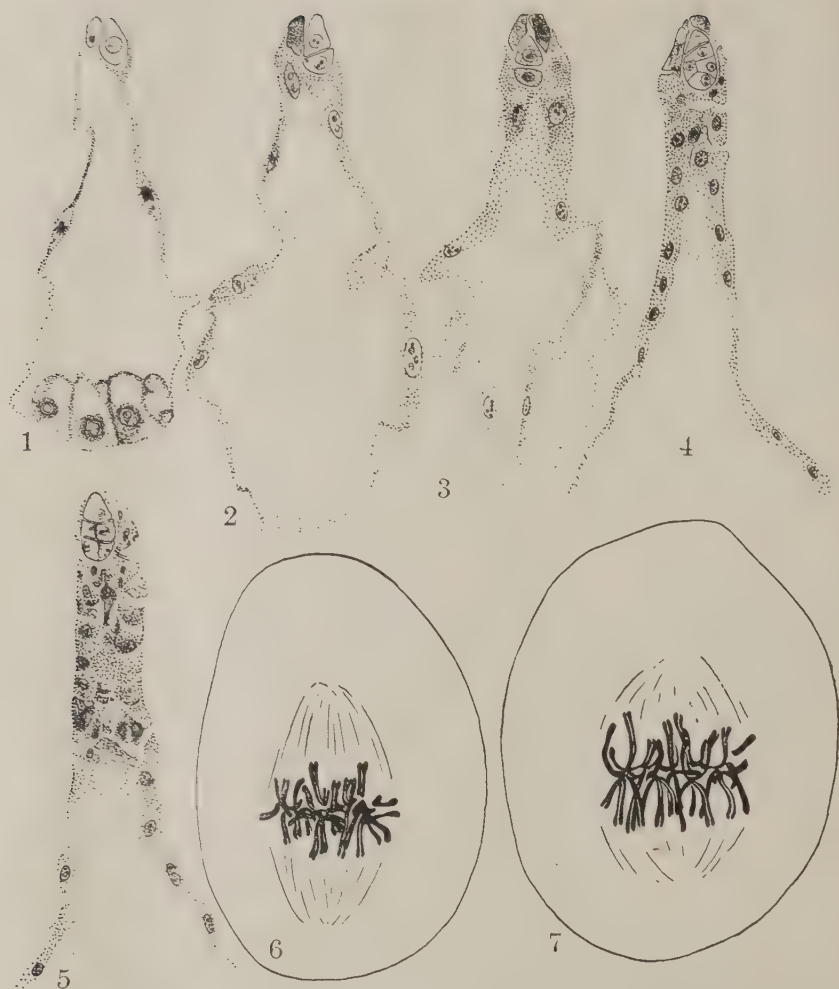
TABLE 7. Chromosome numbers and genom constitution of three *Triticum* species and their hybrid seeds

Combinations of crosses	Chromosome numbers of gametes	Genom constitution of gametes	Genom constitution in the embryo	Genom constitution in the endosperm
<i>T. spelta</i> × <i>spelta</i>	21 × 21	ABD × ABD	2 (ABD)	3 (ABD)
<i>T. polonicum</i> × <i>polonicum</i>	14 × 14	AB × AB	2 (AB)	3 (AB)
<i>T. aegilopoides</i> × <i>aegilopoides</i>	7 × 7	A × A	2 A	3 A
<i>T. spelta</i> × <i>polonicum</i>	21 × 14	ABD × AB	2 (AB) + D	3 (AB) + 2D
<i>T. polonicum</i> × <i>spelta</i>	14 × 21	AB × ABD	2 (AB) + D	3 (AB) + D
<i>T. polonicum</i> × <i>aegilopoides</i>	14 × 7	AB × A	2 A + B	3 A + 2B
<i>T. aegilopoides</i> × <i>polonicum</i>	7 × 14	A × AB	2 A + B	3 A + B
<i>T. spelta</i> × <i>aegilopoides</i>	21 × 7	ABD × A	2 A + BD	3 A + 2 (BD)
<i>T. aegilopoides</i> × <i>spelta</i>	7 × 21	A × ABD	2 A + BD	3 A + BD

The embryological observations were made at 8 successive times, 15, 20, 24, 30, 48, 72, 96 and 120 hours after crossing and self pollination. These cytological observations are given as follows :—

*T. spelta*, *T. polonicum* and *T. aegilopoides*

15 hours : Fertilization has already been completed. Most of the fertilized egg cells remain in the early prophase stage. The chromatin forms a fine threadlike structure. The fertilized egg nucleus contains usually one large nucleolus or several smaller ones. After fertilization the attacked synergid rapidly degenerates, and it remains near the micropylar end as a densely staining mass. The endosperm has in this stage already a number (mostly two) of dividing nuclei (Fig. 1). Many



Figs. 1-4.  $\times 120$ . Development of the embryo and endosperm in *Triticum polonicum* selfed. 1. 15 hours after pollination. The fertilized egg cell one of the synergids, free endosperm nuclei and several antipodals are seen. 2. 24 hours after self pollination. 2-celled proembryo, one of the synergids and free endosperm nuclei are seen. 3. 30 hours after self pollination. 4. 48 hours after self pollination. Cell walls are first formed near the embryo.

Fig. 5.  $\times 120$ . 48 hours after self pollination in *T. spelta*. Cell walls are first formed near the embryo.

Figs. 6 and 7.  $\times 1450$ . The metaphase in the first division of the fertilized egg cells. 6. *T. polonicum*, 24 hours after self pollination. 7. *T. polonicum* ( $\varnothing$ )  $\times$  *spelta* ( $\sigma$ ), 20 hours after cross pollination.

antipodals are always seen at the lateral side or at the chalazal end of the embryo-sac.

20 hours: The chromatin in the fertilized egg of *T. polonicum* forms a thick spireme, but that of *T. spelta* and *T. aegilopoides* remains in the early spireme stage. In all species the number of endosperm nuclei increase more or less and they are distributed in a thin cytoplasmic layer inside of the embryo-sac, but at this stage they have not yet reached the chalazal end. The antipodals gradually enlarge and their contents coagulate in several masses which darkly stain with haematoxylin.

24 hours: In one day after self pollination the fertilized eggs are seen in various stages, according to the difference in species. In *T. polonicum* 2-celled proembryos are usually formed (Fig. 2), but the first division metaphase of the fertilized egg was found in one ovule (Fig. 6). In *T. spelta* the spireme stages are commonly found in the fertilized egg, but the metaphase of the first division in the fertilized egg and 2-celled proembryo is rarely found. In *T. aegilopoides* all fertilized egg cells remain in the spireme stage. In all species the endosperm nuclei are divided more and more and are distributed sporadically through the whole cytoplasmic layer inside of the embryo-sac (Fig. 2).

30 hours: 2-celled proembryos are common in all three species. The successive division of the endosperm nuclei proceeds rapidly and at the same time the cytoplasm increases in volume, especially near the embryo (Fig. 3).

48 hours: 3-5-celled embryos are formed in *T. spelta*, 4-5-celled embryos in *T. polonicum*, and 3-4-celled embryos in *T. aegilopoides*. The endosperm nuclei divide rapidly, especially near the embryo. At the same time the endosperm increases in volume. Therefore, the ovary is much increased in size. In *spelta* and *polonicum*, the formation of the cell walls in the endosperm first occurs at this stage. The first cell wall formation is confined to the region near the embryo. In *polonicum*, it is found in the endosperm very near the embryo (Fig. 4), while in *spelta*, the walls are formed in the large region (Fig. 5). The shape of the cells is irregular because two or more adjacent cells are still connected. They contain dense cytoplasm. The formation of the cell walls in the endosperm is not found in *T. aegilopoides*, while the endosperm nuclei increase with remarkable rapidity. Disorganized synergids lie close to the embryo, and they stain darkly with haematoxylin. The antipodals degenerate and seem to nourish the endosperm,

so that the development of an endosperm connected with the antipodals is very favourable. The nuclear contents of the antipodals coagulate in several masses and they stain deeply with haematoxylin.

72 hours: 6-8-celled embryos are generally found. The successive divisions of the endosperm nuclei continue still further and very rapidly, especially near the antipodal cells. In *T. aegilopoides*, cell walls are first formed in the endosperm near the embryo. In *T. polonicum* (Pl. I, Fig. 1) and *aegilopoides*, the most distant part of the endosperm from the embryo, which forms a hollow sac out of one cytoplasmic layer, contains free endosperm nuclei. The cytoplasmic layer is almost equal in thickness throughout the whole sac, except the part connected with the antipodals. In *T. spelta*, the cell wall formation is much more advanced than in the two species given above. Cell walls are seen in all parts of the endosperm.

I have observed a case of abnormal formation of the embryo in *T. spelta* selfed (Pl. II, Fig. 19), where two embryos were formed in one embryo-sac, one larger than the other. As already described in *Avena*, by KIHARA and NISHIYAMA (1932), the larger one might be developed from the egg cell, and the smaller one from one of the synergids.

96 hours: In the embryo-sac of *T. spelta*, the endosperm increases in volume with remarkable rapidity and fills up the whole cavity of the embryo-sac, while the tissue of the innermost part of the endosperm is still loose. In *T. polonicum*, the development of the endosperm is less advanced (Pl. I, Fig. 2). It is almost at the same stage of development as the endosperm of *T. spelta* 72 hours after self pollination. In the same ovule the tissue near the antipodals consists of more layers, and they contain dense cytoplasm. In *T. aegilopoides*, the development is still slower. The cell wall formation of the endosperm takes place at last near the antipodals. The free division of endosperm nuclei is still continuing in the remaining endospermic layer (Pl. II, Fig. 11). The appearance of the embryo-sac is almost like in *T. spelta* 72 hours after pollination (cf., Pl. I, Fig. 9 and Pl. II, Fig. 11).

120 hours: Five days after self pollination all embryo-sacs of *T. spelta*, *T. polonicum* (Pl. I, Fig. 3) and *T. aegilopoides* are entirely filled with the endosperm tissue. The outermost cells are the smallest and lie compactly. The nearer the cells lie to the center of the endosperm, the greater. The innermost cells have scanty cytoplasm around the nucleus and from there many strands of cytoplasm run



out to the cell wall. The antipodals and synergids are almost entirely dissolved, though remnants of the former remain.

*T. spelta* (♀) × *T. polonicum* (♂)

As the development of the hybrid ovaries proceeds in the same general way as that of the mother plant, this description is confined to point out the differences from the mother plant, to save repetition.

15 hours: 15 hours after cross pollination fertilization has already been completed. The fertilized egg cell shows the early spireme stage. The attacked synergid cell has already degenerated and it stains deeply with haematoxylin.

20 hours: The fertilized egg cell still remains in the early spireme stage. The endosperm increases somewhat in volume. The development of the endosperm is the same as that of the mother selfed.

24 hours: One day after pollination the fertilized egg cell is divided by a transverse wall and results in a 2-celled proembryo.

30 hours: The embryo grows somewhat, but it is still a 2-celled proembryo. The endosperm increases in volume, especially near the embryo.

48 hours: 3-4-celled embryos are formed. The number of free nuclei of the endosperm increases with remarkable rapidity. At the same time the cytoplasmic layer increases in width, especially near the embryo. The cell walls are first seen in the endosperm near the embryo, as is observed in the mother selfed. The synergid is degenerating in the usual way.

72 hours: The development of the endosperm is more rapid than that of *T. spelta* selfed (Pl. I, Fig. 7). The antipodals show marked hypertrophy.

96 hours: The embryo-sac is entirely filled with the endosperm tissue (Pl. I, Fig. 8). The cells of the endosperm tissue show the presence of a small amount of cytoplasm. This corresponds to the stage of development shown by *T. spelta* after 120 hours.

120 hours: The growth of the embryo proceeds rapidly and it consists of numerous cells. The endosperm tissue becomes more compact.

*T. polonicum* (♀) × *T. spelta* (♂)

15 hours: The fertilized egg cell presents the early spireme stage. Several free endosperm nuclei are seen in the thin cytoplasmic layer.

20 hours: Usually the fertilized egg cells remain in the spireme stage, but in some fertilized egg cells the metaphase of the first division is found (Fig. 7). The metaphase stage in the first division of the fertilized egg cell is not found in the parents 20 hours after selfing.

24 hours: 2-celled proembryos are formed. The development of the endosperm is the same as that of the mother selfed.

30 hours: 2-celled proembryos are usually formed, and the free endosperm nuclei increase in number. At the same time the endosperm increases in volume, especially near the embryo.

48 hours: 5-celled embryos are usually formed. The endosperm increases remarkably near the embryo. Cell walls, which have already been formed in the mother selfed, are not yet perceived.

72 hours: The embryo consists of 8 or more cells. Cell walls are first formed in the endosperm near the embryo, but two or more adjacent cells still communicate with each other and their shape is irregular (Pl. I, Fig. 4).

96 hours: The formation of the cell walls is not yet observed in the endosperm except near the embryo (Pl. I, Fig. 5). The development of the embryo and endosperm is like that of *T. polonicum* 72 hours after self pollination (Pl. I, Fig. 1).

120 hours: One or two cell layers of the endosperm tissue are at last formed in the outermost part of the embryo-sac (Pl. I, Fig. 6), contrasting with the fact that at this time the embryo-sac of the parents had already been entirely filled by the endosperm tissue.

*T. polonicum* (♀) × *T. aegilopoides* (♂)

15 hours: The fertilized egg cells show a fine threadlike structure. Several free endosperm nuclei are seen in the thin cytoplasmic layer. The attacked synergids degenerate and lie at the micropylar end of the embryo-sac, staining darkly with haematoxylin.

20 hours: The fertilized egg cells show the spireme stage. The free endosperm nuclei gradually divide.

24 hours: One day after cross pollination the fertilized egg cells show the metaphase of the first division or a more advanced stage. The endosperm increases in volume.

30 hours: 2-celled proembryos are formed. The free endosperm nuclei divide more and more and are distributed through the whole cytoplasmic layer inside of the embryo-sac.

48 hours: 3-5-celled embryos are formed. The endosperm increases with remarkable rapidity. The growth of the endosperm is

especially remarkable near the embryo. Antipodals and synergids are degenerating in the usual way.

72 hours: The embryo consists of 8 or more numerous cells. The cell walls are formed from the endosperm near the embryo, like those in *T. polonicum* selfed. In that part of the cytoplasmic layer at a distance from the embryo free endosperm nuclei continue further to divide. The successive division of the endosperm nuclei is especially notable in the region near the antipodals.

96 hours: The embryo consists of many cells. 3 or 4 cell layers of the endosperm tissue are formed inside of the embryo-sac (Pl. II, Fig. 12), being more numerous near the antipodals. The formation of the cell layers of the endosperm tissue is somewhat more advanced than that of *T. polonicum* selfed.

120 hours: The embryo-sac is entirely filled with the endosperm tissue (Pl. II, Fig. 15).

*T. aegilopoides* (♀) × *T. polonicum* (♂)

15 hours: The fertilized egg cells remain in the early spireme stage. Several free endosperm nuclei are seen in the thin cytoplasmic layer. The attacked synergid cell degenerates rapidly and its content is scanty.

20 hours: The structure of the chromatin in the fertilized egg cell was not clearly observed. The successive division of the endosperm nuclei proceeds slowly.

24 hours: The fertilized egg cells show the metaphase of the first division, or sometimes a more advanced stage. The endosperm nuclei divide more and more and are distributed through the cytoplasmic layer inside of the embryo-sac.

30 hours: 2-celled proembryos are usually formed. The successive division of the endosperm nuclei proceeds favourably. The free endosperm nuclei increase in number, especially near the embryo.

48 hours: The embryo commonly consists of 4 cells. The endosperm nuclei increase in number with remarkable rapidity and are distributed linearly through the whole cytoplasmic layer inside of the embryo-sac.

72 hours: The embryo consists of 8 or more cells. Cell walls are first formed in the endosperm near the embryo.

96 hours: The embryo consists of numerous cells. The cell wall formation of the endosperm is observed in the chalazal end and near

the antipodals (Pl. II, Fig. 13). The cell wall formation in this part follows that of the part near the embryo.

120 hours: Five days after cross pollination the embryo-sac is entirely filled with the endosperm tissue, but the tissue of the innermost part of the endosperm is still loose (Pl. II, Fig. 16).

In this cross the speed of development of the hybrid embryo and endosperm is almost equal to that of the mother selfed.

*T. spelta* (♀) × *T. aegilopoides* (♂)

15 hours: A few fertilized egg cells show the early spireme stage, but the greater number is still in the resting stage. Two or more endosperm nuclei are seen in the thin cytoplasmic layer. The attacked synergids degenerate rapidly.

20 hours: In the fertilized egg cells the spireme is not as yet completely formed.

24 hours: One day after pollination the fertilized egg cells show various stages from the spireme stage to the 2-celled proembryo. The free endosperm nuclei divide more and more and are scattered through the whole cytoplasmic layer inside of the embryo-sac.

30 hours: 2-celled proembryos are generally formed. The successive division of the endosperm nuclei proceeds normally.

48 hours: The embryo consists of 3-4 cells. Cell walls are first seen in the endosperm near the embryo, just as in the mother selfed.

72 hours: 5-8-celled embryos are formed. One or two cell layers of the endosperm tissue are formed in all parts of the cytoplasmic layer (Pl. II, Fig. 10), except the layer near the antipodal cells, where more numerous layers are observed. The growth of the endospermic layers is quicker than in the mother selfed.

96 hours: The material which was prepared for use was injured by the larva of an insect. Therefore I could not observe the full development of the embryo and endosperm. However, in some comparatively well developed ovaries the whole cavity of the embryo-sac was already entirely filled with the endosperm tissue.

120 hours: The embryo consists of many cells. The embryo-sac is entirely filled with the endosperm tissue (Pl. II, Fig. 17).

*T. aegilopoides* (♀) × *T. spelta* (♂)

15 hours: There are usually two endosperm nuclei. The fertilized egg cell is in the resting stage.



20 hours: The endosperm nuclei increase somewhat in number, but the chromatin structure of the egg cell cannot yet be observed.

24 hours: I could not find any sign of prophase in the egg cells, as they remain unstained by haematoxylin.

30 hours: The endosperm increases gradually in volume. At the same time, the free endosperm nuclei increase more and more and are distributed through the cytoplasmic layer inside of the embryo-sac. The nuclear division of the fertilized egg is not observed until this time.

48 hours: 3-4-celled embryos are found suddenly in this time. The size of the embryo-sac grows rapidly. The successive division of the endosperm nuclei occurs rapidly and they are distributed linearly through the whole cytoplasmic layer inside of the embryo-sac. The synergids and antipodals are degenerating in the usual way.

72 hours: The embryo consists of 6-8 cells. The successive division of the endosperm nuclei proceeds normally without the formation of cell walls.

96 hours: The embryo grows somewhat and consists of over 8 cells. Cell walls are first formed from the endosperm near the embryo (Pl. II, Fig. 14). The formation is later than that of the mother selfed (Pl. II, Fig. 11).

120 hours: The embryo consists of many cells, but its external appearance shows an unhealthy development. In this material, only one or two cell layers of the endosperm tissue were formed inside of the embryo-sac (Pl. II, Fig. 18), though the cavity of the embryo-sac of the parents was entirely filled with the endosperm tissue.

#### MEASUREMENTS OF THE OVULE AND EMBRYO

It has already been mentioned that the healthy development of the endosperm tissue is closely dependent on the direction of the cross. It is well known that when a species having a high chromosome number is used as female the size of the hybrid seed is less than when it is used as the male. With regard to the size of the hybrid embryo, KOSTOFF (1930) made an interesting embryological study in *Nicotiana*. He measured the size of the embryos of *N. rustica* ( $x = 24$ ) and its hybrids with species differing in chromosome number. The success of the germination of the hybrid seed was determined by the mean value of the length and the breadth of the embryo. If the embryos



have a smaller value than this established mean value, germination always ends in failure.

I have measured the size of the ovule and embryo of *Triticum* species and of hybrid seeds resulting from the crosses between species with a different chromosome number. The longitudinal sections of the ovaries were cut parallel to the plane of the ventral surface of the ovaries. The length and breadth of the ovules were measured at the widest part. The results are given in Table 8 and 9.

TABLE 8. Mean length and breadth (mm.) of ovules in pure species and in hybrids

Combinations of crosses	Hours					
	15	24	30	48	72	96
Mean length						
<i>T. polonicum</i> × <i>polonicum</i>	0.7308	0.8526	0.8613	1.2677	1.3735	2.4708
<i>T. polonicum</i> × <i>spelta</i>	0.8128	0.8787	1.0266	1.4057	1.9619	2.6622
<i>T. spelta</i> × <i>polonicum</i>	0.8874	0.9266	1.1288	1.3609	1.8727	2.4638
<i>T. spelta</i> × <i>spelta</i>	0.8134	0.8961	1.0440	1.3876	2.4012	2.6035
<i>T. spelta</i> × <i>aegilopoides</i>	0.8515	0.9396	1.0142	1.3115	2.0358	
<i>T. aegilopoides</i> × <i>spelta</i>	0.7569	0.8809	0.9657	1.3050	1.8966	2.5265
<i>T. aegilopoides</i> × <i>aegilopoides</i>	0.6351	0.7264	0.7373	1.2093	1.8344	2.3816
<i>T. aegilopoides</i> × <i>polonicum</i>	0.6623	0.8091	0.8799	1.3311	1.9401	2.6779
<i>T. polonicum</i> × <i>aegilopoides</i>	0.7606	0.9619	1.1309	1.3415	1.4094	2.5764
Mean breadth						
<i>T. polonicum</i> × <i>polonicum</i>	0.4959	0.5786	0.5829	0.6972	0.6982	0.9831
<i>T. polonicum</i> × <i>spelta</i>	0.5593	0.6134	0.6481	0.7152	0.8352	1.0538
<i>T. spelta</i> × <i>polonicum</i>	0.6134	0.6166	0.6297	0.6861	0.8613	1.0544
<i>T. spelta</i> × <i>spelta</i>	0.5263	0.6003	0.6220	0.7308	0.8688	1.1288
<i>T. spelta</i> × <i>aegilopoides</i>	0.5775	0.6351	0.6525	0.6786	0.8178	
<i>T. aegilopoides</i> × <i>spelta</i>	0.4959	0.5155	0.4872	0.5200	0.6089	0.7412
<i>T. aegilopoides</i> × <i>aegilopoides</i>	0.4263	0.4742	0.4763	0.5133	0.5481	0.6590
<i>T. aegilopoides</i> × <i>polonicum</i>	0.4404	0.4829	0.4884	0.5525	0.6047	0.7308
<i>T. polonicum</i> × <i>aegilopoides</i>	0.5257	0.6264	0.6873	0.7256	0.7352	1.0887

In *T. polonicum* ( $x = 14$ ) ♀ × *spelta* ( $x = 21$ ) ♂, the mean length and breadth of the ovules are always larger at any time than those of *T. polonicum* selfed. In the reciprocal cross (*T. spelta* ♀ × *polonicum*

♂), up to 30 hours after cross pollination, the growth of the ovule proceeds more rapidly than that of *T. spelta* selfed, but the subsequent development proceeds slowly and the mean length and breadth of the ovules are less than those of *T. spelta* selfed. In *T. aegilopoides* ( $x = 7$ ) ♀ × *polonicum* ( $x = 14$ ) ♂ and its reciprocal, the mean length and breadth of the ovules are always greater at any time than those of their mother selfed. Like *T. spelta* (♀) × *polonicum* (♂), the growth of the ovule in *T. spelta* ( $x = 21$ ) ♀ × *aegilopoides* ( $x = 7$ ) ♂ proceeds rapidly during the early stages of development, but the subsequent growth proceeds more slowly than that of *T. spelta* selfed. In the reciprocal cross, *T. aegilopoides* (♀) × *spelta* (♂), the mean length and breadth of the ovules are always greater at any time than those of the mother selfed.

TABLE 9. Mean length and breadth (mm.) of embryos in pure species and in hybrids

Combinations of crosses	Mean length (A)	Mean breadth (B)	Mean length or breadth of cross-embryos		Area of embryos (A × B) (mm <sup>2</sup> .)	A × B  Area of selfed mother embryos %
			Mean length or breadth of selfed mother embryos			
			Length	Breadth		
<i>T. polonicum</i> × <i>polonicum</i>	0.1496	0.0897	1.00	1.00	0.0134	100
<i>T. polonicum</i> × <i>spelta</i>	0.1089	0.0643	0.73	0.71	0.0070	52
<i>T. spelta</i> × <i>polonicum</i>	0.1252	0.0737	0.89	0.93	0.0092	84
<i>T. spelta</i> × <i>spelta</i>	0.1392	0.0793	1.00	1.00	0.0110	100
<i>T. spelta</i> × <i>aegilopoides</i>	0.1391	0.0754	0.99	0.95	0.0105	95
<i>T. aegilopoides</i> × <i>spelta</i>	0.0899	0.0576	0.72	0.87	0.0052	63
<i>T. aegilopoides</i> × <i>aegilopoides</i>	0.1252	0.0661	1.00	1.00	0.0083	100
<i>T. aegilopoides</i> × <i>polonicum</i>	0.1136	0.0638	0.91	0.97	0.0072	87
<i>T. polonicum</i> × <i>aegilopoides</i>	0.1438	0.0875	0.96	0.98	0.0126	94

I also measured the size of the embryos. Only embryos 120 hours after self and cross pollination were used for this purpose. The relative size of the embryos in reciprocal crosses is given in % determined by comparing their size with that of the embryos obtained from the selfed mother.

The embryos of hybrid seeds are always smaller than those of the pure species selfed. When the mother has a high chromosome number the embryos are larger than when the mother has a low chromosome number. As I did not use a planimeter for the measurement of the embryos, I had to use the product of the mean length and the mean breadth of the embryo as its area. Hybrid embryos, as compared with those of their mother selfed, varied in their relative size from 95% to 52%.

The relative size of the embryos in *T. polonicum* (♀) × *spelta* (♂) and in *T. aegilopoides* (♀) × *spelta* (♂) are 52% and 63% respectively, viz., the former is somewhat smaller than the latter. But the former germinated fairly well, and the latter did not. An analogous case was found between *T. spelta* (♀) × *polonicum* (♂) and *T. spelta* (♀) × *aegilopoides* (♂). The embryo of the former is smaller than that of the latter, whereas the germination of the seeds of the former is better than that of the latter.

Judging from these facts, the poor development of the embryo in *Triticum* is not a decisive factor in the unfavourable germination of the hybrid seeds. It seems to me that the poor germination of the hybrid seed is due rather to the poor development of the endosperm. The development of the embryo, however, is, to some extent, related to the germination of the seed, because a well germinated seed usually has a well developed embryo, e.g., hybrid seeds from high chromosome number (♀) × low number (♂) have better developed embryos and their germination is better than those from low chromosome number (♀) × high number (♂). Therefore, it is reasonable to deduct that the difference in seed germination in reciprocals depends upon the development of both embryo and endosperm.

Through the embryological studies given above, I was able to form a general rule for the difference in development of the embryo and endosperm in the reciprocal crosses of *Triticum*. The hybrid seeds developed in the following manner in reciprocal crosses between a high chromosome species and a low chromosome species:—if the former was female the endosperm formation proceeded more rapidly than that of the mother selfed, but the ovules were below normal size and the embryos smaller than those of the mother selfed, though larger than those of the reciprocal; if the latter was female the endosperm formation proceeded more slowly than that of the mother selfed, but the ovules were larger than those of the mother selfed, while embryos were smaller than those of the mother selfed and of the reciprocal. In

a cross low chromosome number ( $\varphi$ )  $\times$  high number ( $\sigma$ ), the hybrid ovaries contain much watery content during their development, since the endosperm formation is not accompanied by the growth of the ovule. When the ovaries ripen they shrink in size and finally become wrinkled owing to loss of water. Of course these hybrid seeds show low germination or none at all. In reciprocal crosses between tetraploid and diploid species, the growth of the endosperm shows no particular difference according to the direction of the crosses. As might be expected, the percentage of germination between the hybrid seeds in reciprocal crosses showed a very slight difference.

### Discussion

In many reciprocal interspecific crosses of *Nicotiana* (EAST 1928, CHRISTOFF 1928, KOSTOFF 1930), well germinated seeds were usually obtained from successful cross combinations. When a species with a higher chromosome number was used as the female both the seed set and the germination of the seeds were good, but when it was used as the male they were bad. However, success in pollination and the results of seed germination in reciprocal crosses not always show a positive correlation. Namely, successful pollination is not always accompanied by a good germination of the seeds, and vice versa. For instance, in *Triticum* (WAKAKUWA 1930 and present paper) and *Avena* (KIHARA and NISHIYAMA 1932), when a species with a higher chromosome number is the male the seed set is always good, but the seeds germinate badly; when a species with a lower chromosome number is the male the seed set is always bad, but the seeds germinate well. Therefore, in discussing the seed set and the germination of seeds in reciprocal crosses, the two subjects must be considered separately.

The problem of success in pollination and the differences in seed germination in reciprocal crosses is very complicated. Therefore it will be difficult to give a general rule covering all cases. Accordingly, many authors have their own opinions as to a solution of this subject. Since the problem has often been discussed by many authors (THOMPSON 1930, WATKINS 1932, KIHARA and NISHIYAMA 1932, MÜNTZING 1933, KATAYAMA 1933), I shall not go further into detail in this paper.

KIHARA (1932) has reported interesting results in crossing experiments with mixed pollens of *Triticum durum* ( $x = 14$ ) + *vulgare* ( $x = 21$ ) dusted on the stigma of *T. durum* or *T. vulgare*. When *durum* served



as the female plant, hybrids (pentaploid) and non-hybrids (*T. durum*) were obtained in about equal number, although the number of non-germinated seeds was greater (most non-germinated seeds are probably hybrid seeds as KIHARA suggested). When *vulgare* served as the female plant the ratio was 248 non-hybrids against 26 hybrids. The writer also made similar experiments with different species of *Triticum*, and obtained similar results, as shown in Table 10.

TABLE 10. Competition between pollen tubes with different chromosome numbers

Cross combinations	Kinds and numbers of pollen tubes fertilizing the egg cells			
<i>T. vulgare</i> × ( <i>spelta</i> + <i>durum</i> )	<i>spelta</i>	6	<i>durum</i>	1
<i>T. dicoccum</i> × ( <i>spelta</i> + <i>durum</i> )	<i>spelta</i>	2	<i>durum</i>	1
<i>T. durum</i> × ( <i>dicoccum</i> + <i>aegilopoides</i> )	<i>dicoccum</i>	21	<i>aegilopoides</i>	0

As for the production of seeds in reciprocal crosses between species with different chromosome numbers, WATKINS (1932) concluded that success in pollination depends on the numerical relationship of the chromosomes between the pollen tube and the style. The normal relation of the pollen tube to the style is 1:2. If it is changed to 1: more than 2, the pollen tube growth is still usually normal, but if it becomes 1: less than 2, growth is reduced. In other words, successful pollination is obtained more often from the cross high chromosome number (♀) × low number (♂). According to this hypothesis the pollen tube growth of *vulgare* on the stigma of *durum* should be difficult; but results from experiments showed that the pollen of *vulgare* was able to fertilize the *durum* egg equally well as *durum* pollen. It shows that the pollen tube growth of *vulgare* and *durum* is normal on the stigma of *durum*. THOMPSON (1930 b) also suggested that differences in the difficulty of seed production in reciprocal crosses depend on the same principles as in the case of seed development. Namely, in a cross dinkel wheat ( $x = 21$ ) × emmer wheat ( $x = 14$ ), when the dinkel is the female the endosperm has 3 (14) + 2(7) chromosomes, but when it is the male the endosperm has 3(14) + 7 chromosomes. In the former the extra 7-dinkel chromosomes are diploid and in the latter, haploid. The set of the seed is good when the extra 7-dinkel chromosomes are present in diploid condition in the endosperm. But his hypothesis



does not apply to the case of the seed set in reciprocal interspecific crosses of *Triticum*.

Successful pollination cannot easily be obtained from the speedy growth of pollen tubes only, since JØRGENSEN (1928) observed that while the pollen tube growth of *Solanum luteum* is normal in the style of *S. nigrum*, and the male nucleus enters the egg cell, the male and female nuclei fail to unite (the male nucleus finally degenerating around the female nucleus). Accordingly, successful pollination in *Triticum* includes both proper pollen tube growth and the normal union of corresponding male and female nuclei.

Embryological studies in *Triticum* have shown that the development of the embryo and endosperm in the cross high chromosome number ( $\varnothing$ )  $\times$  low number ( $\sigma$ ) is always better than that in the reciprocal cross. Namely, the development of the embryo and endosperm is always associated with the numerical relationship of the male nuclei to the egg and polar nuclei.

WATKINS (1932) suggested that the development of the seeds depends on the numerical relationship between embryo and endosperm, but it seems to the present author that it depends on the numerical relationship of the male nuclei to the egg and polar nuclei. MÜNTZING (1930 a, b) has reported that the seeds derived from *Galeopsis Tetrahit* ( $n = 16$ ) or *bifida* ( $n = 16$ )  $\times$  *pubescens* ( $n = 8$ ) or *speciosa* ( $n = 8$ ) are non-viable because the embryo and endosperm cease development at an early stage. He suggests that a numerical relationship between the chromosomes of the mother plant, endosperm and embryo is necessary for the full development of the seed. In a pure species the relation is 2:3:2. But in *G. Tetrahit* ( $\varnothing$ )  $\times$  *pubescens* ( $\sigma$ ) the relation is 4:5:3 instead of 2:3:2. When the number of chromosomes in the mother plant is below normal, the seeds are viable. This hypothesis cannot be applied to the unfavourable development of seeds resulting from the cross  $2x(\varnothing) \times 6x(\sigma)$  in *Triticum* (WAKAKUWA 1930 and present paper) and *Avena* (KIHARA and NISHIYAMA 1932). In the cross  $2x(\varnothing) \times 6x(\sigma)$  of *Avena* the embryo and endosperm show abnormal development. MÜNTZING explained that in this case the abnormally low chromosome number of the mother plant is the ultimate cause of the supernormal growth of both embryo and endosperm. But really the unfavourable development of the seeds in  $2x(\varnothing) \times 6x(\sigma)$  is not the cause of the supernormal growth of the embryo and endosperm, but depends on the abnormal nuclear divisions in the endosperm which cause the abortion of the endosperm. In *Triticum*, the growth of the endosperm in

$2x(\text{♀}) \times 6x(\text{♂})$  is very slow compared with the development of the endosperm obtained by  $6x(\text{♀}) \times 2x(\text{♂})$  and of the parental species (cf. Pl. II, Figs. 17 and 18), and does not indicate any sign of supernormal growth during development. Accordingly, production of non-viable seeds cannot be explained from the supernormal growth of the embryo and endosperm, as MÜNTZING believes. In this connection it is very important to note that even the crosses between species with the same chromosome number show great differences in endosperm development (KATAYAMA 1933). The cause of the disturbed seed development is therefore not only due to the numerical relationship of the chromosomes but also to the combination of genomes. The stimulation by the male nucleus of the polar nuclei (KIHARA and NISHIYAMA 1932) can be understood as the genetical compatibility of the paternal and maternal gene complexes, resulting to a normal or abnormal physiological system.

TABLE 11. Relations between direction of crosses, seed set and germination

Combination of crosses	Seed set	Germination	Instances
High chromosome number ( $\text{♀}$ ) $\times$ low number ( $\text{♂}$ )	Good	Good	Most interspecific crosses of <i>Nicotiana</i> (CHRISTOFF 1928)
	Bad	Bad	Unknown
	Good	Bad	Unknown
	Bad	Good	Interspecific crosses of <i>Triticum</i> (the writer) Interspecific crosses of <i>Avena</i> (KIHARA and NISHIYAMA 1932)
Low chromosome number ( $\text{♀}$ ) $\times$ high number ( $\text{♂}$ )	Good	Good	<i>Helianthus cucumerifolius</i> ( $x = 17$ ) $\times$ <i>rigidus</i> or <i>macrophyllus</i> ( $x = 51$ ) (WAGNER 1932)
	Bad	Bad	Most interspecific crosses of <i>Nicotiana</i> (CHRISTOFF 1928)
	Good	Bad	Interspecific crosses of <i>Triticum</i> (the writer) Interspecific crosses of <i>Avena</i> (KIHARA and NISHIYAMA 1932)
	Bad	Good	Unknown
Equal chromosome number	Good	Good	Intraspecific crosses of <i>Triticum</i> (the writer)
	Bad	Bad	<i>Triticum dicoccoides</i> ( $x = 14$ ) $\times$ <i>Aegilops ovata</i> ( $x = 14$ ) (KATAYAMA 1931)
	Good	Bad	<i>Aegilops cylindrica</i> ( $x = 14$ ) $\times$ <i>Triticum dicoccoides</i> ( $x = 14$ ) (KATAYAMA 1931)
	Bad	Good	<i>Triticum durum</i> ( $x = 14$ ) $\times$ <i>Aegilops ventricosa</i> ( $x = 14$ ) (KATAYAMA 1931)

Thus success in pollination and differences in seed germination are generally independent of each other. They are also independent of the numerical difference in chromosomes. Only in related species is the relationship clearly observed (*Triticum* and *Avena*). Combining all possible cases, the seed set and its germination can be theoretically given (table 11).

We can see by a glance at Table 11 that in the cross high chromosome number ( $\varphi$ )  $\times$  low number ( $\sigma$ ) the germination is always good, but bad in the reciprocal cross, except in *Helianthus* crosses. The blank column represents the cross high chromosome number ( $\varphi$ )  $\times$  low number ( $\sigma$ ). This indicates that a triple condition of each single genom is better for the development of the endosperm.

### Summary

(1) The percentage of seed set in reciprocal crosses between *Triticum* species with the same chromosome numbers is high, and there is no difference according to the direction of the cross. The hybrid seed is plump.

(2) All hybrid seeds obtained from crosses between species with the same chromosome numbers show good germination. There is no difference according to the direction of the cross.

(3) In crosses between species with different chromosome numbers, the seed set is always bad when the species with a high chromosome number is female. In the reciprocal cross, however, the seed set is always good. But the seed is plump in the cross high chromosome number ( $\varphi$ )  $\times$  low number ( $\sigma$ ) and wrinkled in the reciprocal.

(4) Germination of hybrid seeds resulting from the cross high chromosome number ( $\varphi$ )  $\times$  low number ( $\sigma$ ) is much better than in the reciprocal cross.

(5) Hybrid seeds from the cross 7-( $\varphi$ )  $\times$  21-chromosome species ( $\sigma$ ) are non-viable. Viable seeds, however, are produced from the reciprocal cross.

(6) Poor germination is always associated with wrinkled seeds.

(7) Fertilization is already completed 15 hours after self or cross pollination.

(8) When the high chromosome species is female and the lower is male, the growth of the endosperm proceeds more rapidly than that of

the mother selfed; but in the reciprocal combination the growth of the endosperm proceeds more slowly than that of the mother selfed.

(9) In *T. polonicum* (♀) × *spelta* (♂) and *T. aegilopoides* (♀) × *spelta* (♂), the ovules are always larger than the mother selfed. But in the reciprocal crosses the growth of the ovules proceeds more rapidly during the early stages of development, while their subsequent development proceeds more slowly than that of the mother selfed. In *T. aegilopoides* (♀) × *polonicum* (♂) and its reciprocal the ovules are always larger than the mother selfed.

(10) Embryos of all combinations between species with different chromosome numbers are smaller than those of the mother selfed. The growth of the embryos is always better in the cross high chromosome number (♀) × low number (♂) than in the reciprocal.

(11) Success in pollination depends on the pollen tube growth and the union of corresponding male and female nuclei.

(12) The difference in endosperm development in reciprocal crosses depends on the difference in the genome constitution of the endosperm. The differences in genome constitution are due to the difference in the numerical relationship of the male nucleus to the polar nuclei. The difference in the development of the embryo in reciprocal crosses is due to the difference in the ratio of the male nucleus to the egg.

(13) The normal relationship of the male nucleus to the polar nuclei is 1:2. If the relation is 1:more than 2 the endosperm development is reduced. The same relationship is observed in the development of the embryo. The normal relationship of the male nucleus to the egg is 1:1; if it changes to 1:more than 1 development is still good but if it becomes 1:less than 1 development is reduced. The development of the hybrid seed depends upon the development of both embryo and endosperm.

(14) In general, the seed set and germination are considered separately and their relationship is brought out in Table 11.

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## Explanation of plates I-II

All figures show the longitudinal section of the ovules.

## PLATE I

Figs. 1-3. *T. polonicum* selfed. 1. 72 hours after self pollination. Cell walls are formed irregularly near the embryo. 2. 96 hours after self pollination. Cell layers of the endosperm tissue are first formed in the lateral side of the embryo-sac. 3. 120 hours after self pollination. The embryo-sac is entirely filled with the endosperm tissue.

Figs. 4-6. *T. polonicum* (♀) × *spelta* (♂). 4. 72 hours after cross pollination. 5. 96 hours after cross pollination. The cell layer is not yet visible (cf. pl. I, figs. 2 and 3). 6. 120 hours after cross pollination. The embryo-sac is not yet filled with the endosperm (cf. pl. I, fig. 3).

Figs. 7 and 8. *T. spelta* (♀) × *polonicum* (♂). 7. 72 hours after cross pollination. Cell layers of the endosperm tissue are formed in the lateral side of the embryo-sac. The formation of the cell layer is earlier than that of the mother selfed (cf. pl. I, fig. 9). 8. 96 hours after cross pollination. The embryo-sac is entirely filled with the endosperm tissue.

Fig. 9. *T. spelta* selfed. 72 hours after self pollination.

## PLATE II

Fig. 10. *T. spelta* (♀) × *aegilopoides* (♂). 72 hours after cross pollination.

Fig. 11. *T. aegilopoides* selfed. 96 hours after self pollination.

Figs. 12 and 13. 96 hours after cross pollination. 12. *T. polonicum* (♀) × *aegilopoides* (♂). 13. *T. aegilopoides* (♀) × *polonicum* (♂).

Fig. 14. *T. aegilopoides* (♀) × *spelta* (♂). 96 hours after cross pollination.

Figs. 15 and 16. 120 hours after cross pollination. 15. *T. polonicum* (♀) × *aegilopoides* (♂). 16. *T. aegilopoides* (♀) × *polonicum* (♂).

Figs. 17 and 18. 120 hours after cross pollination. 17. *T. spelta* (♀) × *aegilopoides* (♂). 18. *T. aegilopoides* (♀) × *spelta* (♂).

Fig. 19. *T. spelta* selfed. 72 hours after self pollination. Two embryos are formed in one embryo-sac; one is larger than the other.









PLATE I





## Carices formosanae

By Jisaburo OHWI

(Received March 29, 1934)

In this paper the writer treated all the Carices of Formosa, and recognised sixty species as seen in the following enumeration. Five of them had not been described before. All of them are indigenous and no introduced species have been recorded. As to the conception and nomenclature of the sections the writer adopted KÜKENTHAL's system<sup>(1)</sup>, adding a few alterations.

The late Prof. B. HAYATA stated that the general flora of the mountain regions of the island is in closer relation to that of Japan proper than to that of China and the Philippine Islands. It is nearly the same with the sedge flora of the island, for most of the Carices are limited to the mountain district.

*Carex Duthiei* C. B. CLARKE which grows on the summit of Mt. Niitaka is a conspicuous representative of the Chinese-Himalayan elements. *Carex subtransversa* C. B. CLARKE is the only plant common to Formosa and the Philippines. Twenty-three species are believed to be endemic to Formosa.

The present study has been made mainly on the materials collected by myself, U. FAURIE, S. NAGASAWA, Y. SHIMADA, and others, kept in the Herbarium of the Kyoto Imperial University.

The writer is much obliged to Prof. G. KOIDZUMI of the Kyoto Imperial University, Prof. Y. YAMAMOTO and Ass. Prof. G. MASAMUNE of the Taihoku Imperial University. For the privilege of examining the type specimens of the late Prof. B. HAYATA, the writer is deeply grateful to Prof. T. NAKAI of the Tokyo Imperial University. Thanks are also due to those who have favoured the writer with their collections of Formosan sedges, especially to Mr. Y. SHIMADA, Mr. T. HOSOKAWA, Mr. N. FUKUYAMA, Mr. T. SUZUKI and others.

1) *Carex alliiformis* C. B. CLARKE in Journ. Linn. Soc. 36 (1903) 270; KÜKENTH. Cyper. Caric. (1909) 618, f. 105.

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(1) KÜKENTHAL: Cyperaceae-Caricoideae in ENGLER Pflanzenr. 4:20, Heft 33 (1909).

Hab.: basi m. Nankotaisan in Taihokushu (J. OHWI n. 2540).  
Species pro Flora Formosae nova!

2) *Carex alterniflora* FRANCH. in Bull. Soc. Philom. Paris, 8:7 (1895) 51 et *Carex* As. Orient. (1898) n. 238, t. 6, f. 2, ex pte.

Hab.: m. Nokogoe (J. OHWI n. 3252). Species ad Floram Formosanam nova!

3) *Carex amami-oshimensis* AKIYAMA Consp. Caric. Japonic. (1932) 186, f. 132.

*Carex brunnea* (non THUNB.) C. B. CLARKE in Journ. Linn. Soc. 36 (1903) 278 ex pte; MATSUM. et HAYAT. Enum. Pl. Formos. (1906) 493; AKIYAMA l.c. ex pte.

*Carex gentilis* var *oshimensis* KÜKENTH. Cyper. Caric. (1909) 603.

Hab.: Hokuto (U. FAURIE n. 22), Maruyama (U. FAURIE n. 823), Kudai-en-shurin in Taihokushu (N. FUKUYAMA n. 3914), Taihoku (J. OHWI!), ibid. (T. TANAKA et Y. SHIMADA n. 13439), Tarokokyo in Karenkocho (J. OHWI n. 1049).

4) *Carex apodostachya* OHWI sp. nov.

§ *Atratae*. Rhizoma caespites parvos formans estoloniferum, culmo 15–30 cm alto tenui triquetro, sub inflorescentia scabro, superne nutante, basi conferte foliato, foliis quam culmo brevioribus mollibus pallide viridibus planis vel marginibus revolutis 2.5–4 mm latis, apice attenuatis acuminatis, sursum marginibus costaque subtus scaberulis, ceterum laevibus, vaginis basilaribus aphyllis fusco-purpureis striatis demum parce reticulatim fissis, spiculis 2–3 fastigiatis vel congestis, terminali clavato-oblonga gynaeandra 15–20 mm longa, lateralibus femineis oblongis vel ovatis densiplurifloris 10–15 mm longis 6–7 mm latis, bracteis squamiformibus vel ima breviter setaceis evaginatiss, squamis conformibus ovatis atrofusces opacis, apice acutis, dorso concolori uninerviis, utriculis squamas superantibus suberectis membranaceis opacis late ovatis subcompressis enerviis glabris flavostamineis fuscovariegatis 4 mm longis, basi rotundata sessilibus, apice subsensim contractis in rostrum breviusculum (fere 2/3 mm longum) cylindricum atrofuscum ore bidentulum, nuce laxe implente obovata 2 mm longa sessili compressiuscule trigona, stylo tenui recto basi aequali, stigmatibus 3 tenuibus brevibus. — A *C. atrata* LINN., cui proxima, bracteis saepius squamiformibus, spiculis lateralibus sessilibus, utriculorum apice minus abrupte abeunte in rostrum longius, nuce laxe sed arctius implente differt.

Hab.: m. Nankotaisan in Taihokushu (J. OHWI n. 4182-Typus), ibid. (N. FUKUYAMA n. 4054; J. OHWI ns. 4013, 4053), m. Tsugitaka (T. HOSOKAWA).

5) *Carex arisanensis* HAYATA Mater. Flor. Formos. (1911) 378 et Icon. Pl. Formos. 6 (1916) 130, t. 18.

§ *Rhomboidales*. Foliorum vaginis exterioribus rubro-purpureis, bracteis inferioribus longe vaginantibus breviter anguste laminatis quam spicula sua multo brevioribus, squamis femineis anguste ovatis pallidibus interdum dilute ferrugineo-suffusis, acutis, carina viridi uninervi angusta, utriculis quam squamis duplo longioribus erecto-patentibus 5.5-6.5 mm longis glabris membranaceis trigonis brunneoviridibus tenuiter plurinerviis late obovatis, basi contracta sessilibus, apice abrupte abeuntibus in rostrum longum e basi lata cylindricum ore hyalino bidentulum, nuce arcte explente late obovata trigona 3 mm longa facie planiuscula, stylo brevi basi aequali, stigmatibus 3 breviter exsertis.—Species ex grege *C. filipedis* FRANCH. et SAVAT.

Hab.: Agyoku in Taihokushu (J. OHWI n. 662), inter Koro et Koro-anbu in Taihokushu (T. SUZUKI n. 8440), in m. Taiheizan (J. OHWI n. 2256), m. Arisan (U. FAURIE ns. 16, 154 ex pte; J. OHWI n. 3509), Chippongoe in Taitocho (J. OHWI n. 1438), prope Daijurin in Taitocho (J. OHWI n. 401), inter Chakon et Rarasan in Taihokushu (J. OHWI n. 831).

6) *Carex baccans* NEES in WIGHT Contr. Bot. Ind. (1834) 122; MATSUM. et HAYATA Enum. Pl. Formos. (1906) 493; HAYATA Icon. Pl. Formos. 6 (1916) 122, f. 36 a-f.

Hab.: Agyoku in Taihokushu (J. OHWI n. 580), inter Hattsukan et Rakuraku (J. OHWI ns. 3826, 3828), Shirin in Taihokushu (T. TANAKA et Y. SHIMADA n. 13438), m. Shichiseizan (J. OHWI n. 11), Tompo, basi m. Niitaka (S. NAGASAWA), inter Urai et Shinten prope Taihoku (S. KITAMURA n. 420), Hokuto (U. FAURIE n. 3; S. MIKI), Bankinsing (U. FAURIE n. 4), Bunkiko (U. FAURIE sin. num.), Kudai-enshurin in Taihokushu (N. FUKUYAMA n. 3915).

7) *Carex bilateralis* HAYATA Mater. Flor. Formos. (1911) 380 et Icon. Pl. Formos. 6 (1916) 127, f. 40 e-i.

*Carex kotoensis* HAYATA Gener. Ind. Flor. Formos. (1916) 90, nom.

§ *Graciles*. Bractea ima subfoliacea vel setacea quam spicula longiore, basi vaginante, superioribus multo reductis, squamis femineis



oblongis vel anguste oblongis pallide cinnamomeo-suffusis multinervosis acutis vel subacutis, maturitate deciduis, dorso viridi trinerviis, utriculis quam squamis sesquiplo longioribus erectis laxiuscule imbricatis tenuiter membranaceis, praeter marginem acutam hispidulam glabris biconvexis compressis 4 mm longis flavo-viridulis tenuiter plurinervosis ovatis, basi contracta distincte stipitatis, apice sensim contractis in rostrum sublongum e basi lata sursum angustatum ore hyalino bidentatum, nuce arcte nidulante compressa elliptica 2 mm longa, stylo brevi basi subincrassato, stigmatibus 2 tenuibus mediocriter longis. — *C. stipitinuci* C.B. CLARKE affinis.

Hab.: Arisan (J. OHWI n. 3404), inter Ekijukei et Kiritto in Taihokushu (J. OHWI n. 3901), m. Arisan 2500 m. (U. FAURIE n. 21).

8) *Carex Boottiana* HOOK. et ARN. Bot. Beech. Voy. (1841) 273.

*Carex Wahuensis* var. *robusta* et *Bongardi* FRANCH. et SAVAT. Enum. Pl. Japon. 2 (1879) 563.

*Carex reflexistyla* HAYATA Mater. Flor. Formos. (1911) 392 et Icon. Pl. Formos. 6 (1916) 133, f. 44.

Hab.: ins. Kotosho (T. KAWAKAMI et U. MORI n. 2431 in Hb. Tokyo Imp. Univ.!).

9) *Carex brachyathera* OHWI sp. nov.

§ *Ferrugineae*. Rhizoma breviusculum ascendens subcaespitosum, ad collum comose brunneofibrillosum, culmo 40–50 cm alto erecto sed superne nutanti tenui triquetro, imprimis sursum aculeolis longiusculis parce scabro, foliis quam culmo brevioribus planis vel raro conduplicato-planis laete viridibus coriaceis 1.5–2.5 mm latis, utrinque striatis, apice sensim attenuatis et longe acuminatis, supra scabriusculis, margine interdum inflexo scabris, vaginis brunneis cito in fibris parallelis solutis opacis, spiculis 3–5 contiguis nutantibus, terminali subclavato-lineari basin versus laxiflora 2–2.5 cm longa longe pedunculata, lateralibus femineis cylindraceis plurilaxifloris tamen inferioribus remotifloris, omnibus 2.5–3.5 cm longis 3–3.5 mm latis longe et exserte pedunculatis, pedunculis setaceis triquetris scabris, bracteis omnibus vaginantibus breviter laminatis, laminis setaceis, superioribus quam vagina brevioribus, inferioribus 4–6 cm longis, vaginis infimis 3–4 cm longis arctiusculis viridulis interdum antice pallide ferrugineo-suffusis, squamis femineis oblongis castaneoferrugineis, margine superne albo-hyalinis, e dorso viridi trinervi super apicem truncato-emarginatum aristato-cuspidatis, utriculis squamas subsuperantibus vel

aequantibus erectis ovali-fusiformibus membranaceis flavo-viridulis saepe ferrugineo-variegatis 4-5 mm longis, praeter costas 2 nerviis adpresse hirtulis compresse trigonis, utrinque aequaliter abrupte attenuatis, stipite conspicuo glabro incurvo, rostro longo recto cylindrico saepius ferrugineo-tincto, margine hirtulo-scabro, ore hyalino oblique secto demum bidentulo, nuce arcute inclusa compresse trigona ovata 2 mm longa, medio dorso unicostata, stylo recto basi incrassato, stigmatibus 3.—Habitu *C. stenanthae* FRANCH. et SAVAT. proxima.

Hab.: cacumine m. Nankotaisan (J. OHWI n. 4067-Typus), ibid. (J. OHWI n. 4022; N. FUKUYAMA n. 4069), m. Taihasenzan (N. FUKUYAMA), m. Nokogoe (J. OHWI ns. 3167, 3282, 3283), m. Niitaka (J. OHWI n. 3677).

9) *Carex breviculmis* R. BR. subsp. *Royleana* KÜKENTH. Cyper. Caric. (1909) 469; MATSUM. et HAYATA Enum. Pl. Formos. (1906) 493 (pro var.).

*Carex breviculmis* (vix R. BR.) HAYATA Icon. Pl. Formos. 6 (1916) 125.

*Carex morrisonicola* HAYATA Mater. Flor. Formos. (1911) 387 et l.c. (1916) 125.

Hab.: Taitum (U. FAURIE n. 870), prope Pianan-ambu (N. FUKUYAMA; J. OHWI n. 2813), inter Aderu et Shimo-paiwan in Takaoshu (J. OHWI n. 1632), m. Daisuikutsu (J. OHWI n. 3780), Nokogoe (J. OHWI n. 3110), m. Niitaka (J. OHWI ns. 3673, 3703, 3745, 3752), m. Shichiseizan (J. OHWI n. 8), ins. Sharyoto prope Kelung (J. OHWI n. 128), m. Nankotaisan (J. OHWI ns. 2581, 4112, 4125).

var. *fibrillosa* KÜKENTH. ap. MATSUM. et HAYATA Enum. Pl. Formos. (1906) 493 (pro *C. breviculmi* var.).

*Carex breviculmis* subsp. *Royleana* var. *pluricostata* KÜKENTH. Cyper. Caric. (1909) 470.

Hab.: littore Tamsui (U. FAURIE n. 822; J. OHWI n. 145).

11) *Carex brevicuspis* C.B. CLARKE in Journ. Linn. Soc. 36 (1903) 277; KÜKENTH. Cyper. Caric. (1909) 630.

Hab.: Ekijukei in Taihokushu (J. OHWI ns. 2690, 2698), inter Chippon et Miharashi in Taitocho (J. OHWI ns. 1392, 1399), m. Shakarotaisan in Shinchikushu (N. FUKUYAMA). Haec planta ad Floram Formosanam nova!

12) *Carex Brownii* TUCKERM. Enum. Meth. Caric. (1843) 21.

Hab.: prope Pianan-anbu in Taichushu (J. OHWI n. 2768). Species pro Flora Formosae nova!

13) *Carex chrysolepis* FRANCH. et SAVAT. var. *odontostoma* OHWI in Mem. Coll. Sci. Kyoto Imp. Univ. ser. B, 6:5 (1931) 250.

*Carex gokwanensis* HAYATA Icon. Pl. Formos. 10 (1921) 65, f. 42.

Hab.: m. Daibusan in Takaoshu (J. OHWI n. 1830), m. Niitaka (J. OHWI ns. 3661, 3672, 3876), m. Nokogoe (J. OHWI ns. 3111, 3157, 3278).

14) *Carex cruciata* WAHLENB. Inledn. t. Caricogr. (1803) 149; MATSUM. Ind. Pl. Japon. 2:1 (1905) 106; MATSUM. et HAYATA Enum. Pl. Formos. (1906) 494.

*Carex valida* NEES in WIGHT Contr. Bot. Ind. (1834) 123 ex pte; HENRY List Pl. Formos. (1896) 106; MATSUM. Ind. Pl. Japon. 2:1 (1905) 136.

*Carex filicina* (non NEES) MATSUM. et HAYATA l.c. (1906) 495; HAYATA Icon. Pl. Formos. 6 (1916) 122.

*Carex hakkuensis* HAYATA l.c. (1916) 122, f. 37.

Hab.: Nokogoe (N. FUKUYAMA; J. OHWI n. 3254), inter Pianan-ambu et Shikikun (J. OHWI n. 4269), Agyoku in Taihokushu (J. OHWI n. 696), inter Chakon et Rarasan in Taihokushu (J. OHWI n. 855), inter Urai et Agyoku (J. OHWI ns. 751, 752), Shakko (U. FAURIE n. 2), m. Arisan (U. FAURIE n. 1), Toyen (T. ITO), inter Urai et Shinten (S. KITAMURA n. 418), Bunkiko (U. FAURIE n. 230).

15) *Carex cryptostachys* BRONGN. in DUPERRY Voy. Conq. Bot. (1828) 152, t. 25; BOOTT Ill. Carex 3 (1860) 103; MATSUM. et HAYATA Enum. Pl. Formos. (1906) 494.

Hab.: Kelung (U. FAURIE ns. 6, 821), inter Kizan et Kashosho in Taihokushu (T. SUZUKI n. 8367).

16) *Carex daibuensis* HAYATA Icon. Pl. Formos. 10 (1921) 61.

§ *Mitratae*. Spiculis masculis longe linearibus 3-5 cm longis, femineis subtaxifloris, bracteis setaceis basi longe tubuloso-vaginantibus, squamis femineis brunneo-fulvis ellipticis vel obovatis marginibus dilutioribus, apice rotundatis vel emarginatis, ex dorso lato pallide viridi demum stramineo valide tricostato breviter cuspidatis, utriculis squamis longioribus suberectis stramineo-viridibus membranaceis obtuse trigonis ovato-fusiformibus 3 mm longis multicostatis parce puberulis, basi contracta breviter stipitatis, apice sensim abeuntibus in rostrum subbreve conicum subexcurvum basi leviter inflatum ore albido emar-

ginatum, nuce arcte inclusa anguste ovata obtuse trigonâ 2 mm longa, basi cuneata subexcavata, apice in rostrum latum truncatum brevem sensim abeunte, stylo brevissimo conico, stigmatibus 3 breviter exsertis.—E grege *C. conicae* BOOTT. *C. transalpina* HAYATA, mihi non satis nota, forsan huic referenda?

Hab.: Tarokokyo (J. OHWI ns. 1065, 1162; M. TATEWAKI et S. KITAMURA), inter Bunakkei et Pianan-ambu in Taihokushu (J. OHWI n. 4215), inter Kyanrawa et Shikikun in Taihokushu (J. OHWI n. 2429), inter Sansyo et Suigen in Taihokushu (T. SUZUKI n. 8646), m. Daibusan (J. OHWI n. 1794), Nokogoe (J. OHWI ns. 3083, 3142), inter Pianan-ambu et Shikayosha in Taichushu (J. OHWI n. 2791), m. Taiheizan (J. OHWI n. 2322), m. Nankotaisan (J. OHWI n. 2572).

17) *Carex dissitiflora* FRANCH. var. *taiwanensis* OHWI var. nov.

Culmo humiliore, foliis duplo angustioribus a typo diversa.

Hab.: inter Hattsukan et Rakuraku in Taichushu (J. OHWI-Typus), Arisan-Tahtaka (J. OHWI n. 3609), m. Rarasan in Taihokushu (J. OHWI n. 990), inter Yappitu et Dogan in Taihokushu (T. SUZUKI n. 8726), Nokogoe (J. OHWI n. 3385).

18) *Carex dolichostachya* HAYATA Icon. Pl. Formos. 10 (1921) 61, f. 38.

*Carex rankanensis* HAYATA l. c. (1921) 64, f. 41.

*Diplocarex Matsudai* HAYATA l. c. (1921) 70, f. 47.

§ *Mitratae*. Bracteis longe vaginantibus breviter laminatis, squamis femineis ellipticis pallidis vel pallide straminescentibus, apice rotundatis, e dorso viridi anguste trinervi breviter mucronatis subpersistentibus, utriculis suberectis laxè imbricatis quam squamis longioribus pallide viridibus membranaceis anguste ovatis 3–4 mm longis plurinervosis sparse pilosulis obtuse trigonis, basi cuneata breviter stipitatis, apice in rostrum breve conicum ore hyalino bidentulum subabrupte contractis, nuce arcte explente ovata 2–2.5 mm longa trigona, apice contracta et discum parvum portante, stylo brevi basi incrassato, stigmatibus 3 longiusculis deciduis.—Species *C. multifoliae* OHWI similis, sed omnibus partibus viridulis.

Hab.: Chippongoe (J. OHWI n. 1488), Agyoku (J. OHWI n. 530), m. Arisan (J. OHWI n. 3555), Urai (U. FAURIE n. 7), Kelung (U. FAURIE n. 8; S. KITAMURA et T. HOSOKAWA n. 2557), m. Shokoizan (T. HOSOKAWA n. 2591), Tojimpo in Karenkocho (J. OHWI n. 1345), m. Shichiseizan (J. OHWI n. 36), inter Chakon et Rarasan (J. OHWI n. 859), Koko in Taihokushu (T. SUZUKI n. 8358).

19) *Carex Dunni* HAYATA Mater. Fl. Formos. (1911) 382 et Icon. Pl. Formos. 6 (1916) 133.

*Carex Tatewakiana* OHWI in Acta Phytotax. et Geobot. 1 (1932) 299.

Hab.: inter Chakon et Rarasan in Taihokushu (J. OHWI ns. 870, 902), inter Hinokiyama et Rarasan (N. FUKUYAMA n. 4047), Baibara in Taichushu (M. TATEWAKI).

20) *Carex Duthiei* C. B. CLARKE in HOOK. fil. Fl. Brit. Ind. 6 (1894) 731 et in Journ. Linn. Soc. 36 (1903) 284.

Hab.: cacumine m. Niitaka (J. OHWI ns. 3671, 3707). Species ad Floram Formosanam nova est!

21) *Carex Fernaldiana* LÉV. et VAN. in Bull. Acad. Intern. Geogr. Bot. 10 (1901) 276.

Hab.: m. Nankotaizan (J. OHWI n. 2589), m. Niitaka (J. OHWI n. 3720). Nova ad Floram Formosanam!

22) *Carex filicina* NEES in WIGHT Contrib. Bot. India (1834) 123; KÜKENTH. Cyper. Caric. (1909) 274.

*Carex pseudo-filicina* HAYATA Mater. Flor. Formos. (1911) 391 et Icon. Pl. Formos. 6 (1916) 122, f. 36 g-k.

Hab.: m. Arisan (U. FAURIE ns. 11, 18, 229; K. MAYEBARA n. 159; M. TATEWAKI; J. OHWI ns. 3407, 3408, 3411), Bunkiko (U. FAURIE n. 228), Rarasan-ambu (N. FUKUYAMA n. 4049), Pianan-ambu (J. OHWI 2881), m. Nankotaisan (J. OHWI n. 2608), prope Daijurin (J. OHWI n. 356), Chippongoe (J. OHWI n. 1403), m. Shichiseizan (J. OHWI n. 34), m. Taiheizan (N. FUKUYAMA n. 4068).

23) *Carex formosensis* LÉV. et VAN. in Mem. Soc. Nat. Sci. Nat. et Math. Cherb. 35 (1905) 216 et in Fedde Repert. 5 (1908) 31.

*Carex ligata* var. *brevivaginosa* KÜKENTH. ap. MATSUM. et HAYATA Enum. Pl. Formos. (1906) 495 nomen.

*Carex ligata* var. *formosensis* KÜKENTH. Cyper. Caric. (1909) 474; HAYATA Icon. Pl. Formos. 10 (1921) 64.

*Carex kelungensis* HAYATA l. c. (1921) 63.

Hab.: Kelung (U. FAURIE ns. 31, 827; T. Ito), ins. Sharyoto prope Kelung (J. OHWI n. 159).

24) *Carex fulvo-rubescens* HAYATA Mater. Flor. Formos. (1911) 383 et Icon. Pl. Formos. 6 (1916) 127, f. 39 f-j.

§ *Ferrugineae*. Spicula terminali mascula vel raro gynaecandra, bracteis setaceis longe vaginantibus, superioribus in vaginam tubulosam ore fulvam reductis, squamis femineis lanceolatis fulvis acutissimis,



dorso viridulo angusto uninervi, utriculis squamas superantibus aequalis lanceolatis tenuiter membranaceis 5–6 mm longis subcompressis trigonis parce adpresse puberulis tenuiter nervulosis fulvo-virescentibus. marginibus acutis superne hispidulis, basi attenuatis, apice sensim attenuatis in rostrum longum (1.5 mm) excurvum lineare fulvum ore concolori bidentatum, nuce medio utriculi subarcte nidulante fere 1.5 mm longa compressa trigona oblonga, basi stipite recto 1.5 mm longo sustentata, stylo recto tenui basi aequali, stigmatibus 3 tenuibus medio-criter longis.—Species e grege *C. scabrivostris* KÜKENTH.

Hab.: Chippongoe in Takaoshu (J. OHWI n. 1582), Nokogoe in Karenkocho (J. OHWI n. 2925), Chippongoe in Taitocho (J. OHWI n. 1434), Tarokokyo (J. OHWI n. 1051).

25) *Carex gentilis* FRANCH. in Bull. Soc. Philom. Paris, 8:7 (1895) 84 et *Carex* As. Orient. (1896) n. 70, t. 4, f. 2; KÜKENTH. Cyper. Caric. (1909) 603.

*Carex Nakaharai* HAYATA Mater. Flor. Formos. (1911) 387 et Icon. Pl. Formos. 6 (1916) 127, f. 40 a-d.

Hab.: Chippongoe (J. OHWI n. 1491), inter Shikikun et Pianan-ambu (J. OHWI n. 2703), Nokogoe (J. OHWI n. 2952 ex p.), inter Urai et Rahau (N. FUKUYAMA n. 4048), inter Rarasan et Piasan (N. FUKUYAMA ns. 4046, 4052), m. Daibusan (N. FUKUYAMA), m. Arisan (U. FAURIE n. 231; M. TATEWAKI), inter Shikikun et Mera in Taihokushu (N. FUKUYAMA n. 4074).

26) *Carex gracilispica* HAYATA Icon. Pl. Formos. 10 (1921) 62, f. 39.

§ *Mitratae*. Bracteis inferioribus viridibus foliaceis inflorescentiam densimultifloram subaequantibus basi vaginatis, superioribus in vaginam apice breviter setaceam reductis, squamis femineis obovatis sordide lutescentibus obsolete plurinervulosis, margine dilutioribus, apice truncatis, e dorso viridulo trinervi mucronatis, utriculis quam squamis subduplo longioribus suberectis membranaceis pallide viridibus lageniformibus obtuse trigonis 5 mm longis multinervosis puberulis, e basi ovata stipitata in cylindrum brevem angustatis, apice in rostrum breve rectum ore leviter bidentatum abeunte, nuce subarcte implente oblongo-ovata trigona 3 mm longa stipitata, basi cuneata et facie concava, apice sensim transeunte in rostrum  $2/3$  mm latum ac longum truncatum, stylo brevi basi incrassato, stigmatibus 3 tenuibus breviter exsertis.—Species e grege *C. ligatae* BOOTT.

Hab.: inter Chakon et Rarasan in Taihokushu (J. OHWI n. 871), inter Asahi et Yappitu in Taihokushu (T. SUZUKI n. 8771), Agyoku (J. OHWI ns 559, 643), Baibara in Taichushu (M. TATEWAKI).

27) *Carex grallatoria* MAXIM. in Mél. Biol. 12 (1886) 560.

Hab.: m. Rarasan in Taihokushu (J. OHWI n. 937). Haec planta est ad Floram Formosanam nova!

28) *Carex Hatusimana* OHWI sp. nov.

§ *Mitratae*. Rhizoma abbreviatum caespitosum estoloniferum, ad collum dense brunneo-fibrillosum, culmo intra folia abscondito 5–10 cm longo erecto triquetro, foliis quam culmo multo longioribus 20–50 cm longis 2–3 mm latis planis vel conduplicatoplanis coriaceis laete viridibus, apice sensim attenuatis acuminatis, utrinque elevato-pluri-costatis, subtus laevibus, supra scabris, marginibus laeviusculis, vaginis brunneis cito in fibris solutis, saepius asperulatis opacis, spiculis 4–6 fastigiatis erectis singulis simplicibus, terminali mascula lineari laxa 1–2 cm longa breviter pedunculata, lateralibus breviter cylindricis incluse pedunculatis 1–2 cm longis laxi et pauci-pluri-floris, rhachibus rachillisque acute triquetris scabris, bracteis inferioribus 2–3 foliaceis culmo multo longioribus, basi breviter (2–5 mm) laxe vaginantibus, squamis masculis stramineo-brunneis margine albescentibus, nervo unico concolori ante apicem rotundatum saepius erosulum evanido, squamis femineis quadratoellipticis brunneo-stramineis, marginibus albo-hyalinis, apice truncato-rotundatis saepe erosulis et mucronatis, dorso concolori uninerviis, utriculis squamis subduplo longioribus suberectis stramineo-viridibus membranaceis multinervosis 5.5–6.5 mm longis adpresse puberulis, e basi rhomboidea abrupte breviter stipitata sursum breviter tubulosis lageniformibus, apice abrupte contractis in rostrum breve breviter cylindrico-conicum ore albido bidentatum, nuce arete inclusa trigona 4 mm longa ovato-rhomboidea, basi crasse stipitata, apice producta in collum breviter cylindricum teres 1 mm longum 2/3 mm latum apice truncatum, stylo brevissimo, basi incrassato, stigmatibus 3 brevibus tenuibus.—Species e grege *C. breviscapae* C. B. CLARKE.

Hab.: prope Daijurin in Takaoshu (J. OHWI n. 329-Typus), inter Aderu et Shimo-paiwan in Takaoshu (J. OHWI n. 1630), Sekiteisho-kanko in Taihokushu (S. HATUSIMA), inter Kiriyaama et Matsuyama in Taitocho (J. OHWI n. 1476).

29) *Carex hebecarpa* C. A. MEY. Cyp. Nov. (1831) 223, t. 12; KUNTH Enum. Pl. 2 (1837) 471; KÜKENTH. Cyper. Caric. (1909) 744.

Hab.: Sankyaku in Shinchikushu (Y. HIRAKAWA in 1930). Ad Floram Formosanam nova est!

30) *Carex hoozanensis* HAYATA Icon. Pl. Formos. 10 (1921) 67, f. 44.

§ *Rhomboidales*. Squamis femineis oblongis pallidis, apice obtusis, e dorso late viridi tricostrato in aristam validam tricostratam scabram abeuntibus, utriculis quam squamis (absque arista) subtriplo longioribus oblongo-fusiformibus 7-9 mm longis viridulis obsolete trigonis glabris multinervosis, basi cuneata subsessilibus, apice sensim contractis in rostrum sublongum rectum cylindricum ore hyalino bidentatum, nuce arcte explente 4-5 mm longa obovata obtuse trigona, apice in collum breve crassum contracta et in discum crassum subglobosum fere 1 mm diam. dilatata, stylo brevi recto basi incrassato, stigmatibus 3 breviter exsertis.

Hab.: m. Howozan (B. HAYATA! in Hb. Tokyo Imp. Univ. et in Governm. Herb. Taihoku), prope Daijuri in Takaosha (J. OHWI n. 372).

31) *Carex Kobomugi* OHWI in Mem. Coll. Sci., Kyoto Imp. Univ. ser. B, 5:3 (1930) 281 et in Acta Phytotax. et Geob. 2 (1933) 274 in obs.

*Carex macrocephala* (non WILLD.) SASAKI List Pl. Formos. (1928) 83.

Hab.: sine loco speciali (fide SASAKI l. c.), prope Fukikaku (fide N. FUKUYAMA olim).

32) *Carex ligulata* NEES in WIGHT Contr. Bot. India (1834) 127; BOOTT Ill. Carex 1 (1858) 45, t. 113; C. B. CLARKE in Journ. Linn. Soc. 36 (1903) 294.

*Carex hebecarpa* var. *ligulata* FRANCH. Carex As. Orient. (1898) n. 246; HAYATA Icon. Pl. Formos. 6 (1916) 133, f. 42, f-i.

Hab.: inter Aderu et Shimopaiwan in Takaosha (J. OHWI n. 1633), inter Pianan-ambu et Shikayosha in Taichushu (J. OHWI n. 2817), m. Rokujotaisan in Shinchikushu (N. FUKUYAMA).

33) *Carex longistipes* HAYATA Icon. Pl. Formos. 10 (1921) 66.

§ *Decorae*. Squamis femineis fulvescentibus, marginibus dilutioribus ciliatis, apice acutis, dorso pallide viridi uninerviis, utriculis perdense imbricatis quam squamis subduplo longioribus adpressis oblan-  
ceolatis compressis tenuiter membranaceis 5 mm longis fulvo-viridibus tenuiter hirtulis tenuiter paucinerviis, margine acuto superne hispidulis, basi sensim angustata sessilibus, apice abrupte attenuatis in rostrum rectum breve latiusculum ore fulvo bidentatum, nuce supra medium utriculi laxè nidulante oblonga 1.5 mm longa compressa trigona, basi

longe stipitata, stylo brevi basi aequali, stigmatibus 3 mediocribus.  
—Species ex grege *C. longicuspidis* BÖCKLR.

Hab.: Ako (Y. MATSUDA! in Hb. Tokyo Imp. Univ.).

34) *Carex lutchuensis* OHWI in Mem. Coll. Sci., Kyoto Imp. Univ. ser. B, 5:3 (1930) 270.

*Carex obtuso-bracteata* HAYATA Icon. Pl. Formos. 6 (1916) 131 nom.

Hab.: m. Horanzan (LEG.? in Hb. Tokyo Imp. Univ.!).

35) *Carex macrandrolepis* LÉVEILLÉ in Fedde Repert. 5 (1908) 241; OHWI in Mem. Coll. Sci. Kyoto Imp. Univ. ser. B, 5:3 (1930) 255.

*Carex sharyotensis* HAYATA Icon. Pl. Formos. 10 (1921) 69, f. 46.

Hab.: Tarokokyo (J. OHWI n. 1158), m. Nankotaisan (J. OHWI n. 2619), Nokogoe (J. OHWI ns. 3135, 3346), Baibara in Taichushu (M. TATEWAKI), m. Arisan (U. FAURIE n. 34), insl. Sharyoto prope Kelung (J. OHWI ns. 154, 169, 182).

36) *Carex maculata* BOOTT in Trans. Linn. Soc. 20 (1846) 128 et Ill. Carex 1 (1858) 9, t. 26; MATSUM. et HAYATA Enum. Pl. Formos. (1906) 495; HAYATA Icon. Pl. Formos. 10 (1921) 60.

Hab.: m. Shichiseizan (Y. SHIMADA n. 4419; J. OHWI ns. 2009, 2032), m. Daitonzan (T. HOSOKAWA).

37) *Carex manca* BOOTT in BENTH. Fl. Hongk. (1861) 402 et Ill. Carex 4 (1867) 131, t. 425.

Hab.: inter Matsuyama et Aderu in Takaoshu (J. OHWI n. 1526), Pianan-ambu in Taihokushu (J. OHWI ns. 2754, 2804), Tarokokyo (M. TATEWAKI et S. KITAMURA; J. OHWI ns. 1057, 1058, 1219), inter Chakon et Rarasan in Taihokushu (J. OHWI n. 856), m. Shakaro-taisan in Shinchikushu (N. FUKUYAMA), inter Mohen et Riyohen in Taihokushu (T. SUZUKI n. 8888). Haec planta est ad Floram Formosanam nova!

38) *Carex metallica* LÉVEILLÉ in Fedde Repert. 5 (1908) 239; OHWI in Mem. Coll. Sci., Kyoto Imp. Univ. ser. B, 6:5 (1931) 248.

*Carex pachinensis* HAYATA Icon. Pl. Formos. 10 (1921) 58, f. 33.

*Carex alliiformis* (non C. B. CLARKE) HAYATA l. c. 67, f. 43.

Hab.: Toyen (U. FAURIE n. 14), Pachina (U. FAURIE).

39) *Carex Morii* HAYATA Icon. Pl. Formos. 6 (1916) 135, f. 46 et 10 (1921) 64.

§ *Decorae*. Spiculis 1–2 cm longis androgynis numerosis paniculam angustam laxiusculam formantibus, bracteis inferioribus breviter foliaceis basi vaginam longam badiam formantibus, superioribus



spathaceis, squamis conformibus badio- usque fulvo-brunneis ovato-deltaideis multinervulosis, basi amplexantibus, apice acutiusculis, margine anguste albo-hyalinis, dorso angusto viridulo demum concolori uninerviis, utriculis quam squamis plus duplo longioribus late lanceolatis ca. 6 mm longis, e basi suberecta sursum valide excurvis, plano-convexis pallide viridibus multinervosis membranaceis hirtulis, basi cuneata subsessilibus, apice breviter attenuatis in rostrum breviusculum complanatum ore hyalino oblique sectum demum bidentatum, nuce arcte nidulante anguste oblonga 3.5-4 mm longa compresse trigona breviter stipitata, apice in stylum continuantem 2 mm longum rectum infra medium usque ad basin cylindrico-incrassatum contracta, stigmatibus 3 tenuibus breviter exsertis.—Utriculo *C. Reinii* Franch. et Savat. sat similis sed inflorescentiae structura valde diversa est.

Hab.: prope Daijuri in Takaoshu (J. OHWI ns. 325, 393), m. Sendanyama in Taihokushu (T. SUZUKI n. 1482), Tojimpo in Karenkocho (J. OHWI n. 1347).

40) *Carex orthostemon* HAYATA Mater. Fl. Formos. (1911) 389 (incl. var. *cupulifera* HAYATA), et Icon. Pl. Formos. 6 (1916) 126, f. 38 f-i.

Hab.: m. Arisan (U. FAURIE n. 28; M. TATEWAKI; K. MAYEBARA; J. OHWI ns. 3454, 3632), Chippongoe (J. OHWI n. 1447), prope Daijuri (J. OHWI ns. 291, 326).

41) *Carex oxyandra* KUDO Rep. Veget. N. Saghal. (1924) 72; OHWI in Mem. Coll. Sci., Kyoto Imp. Univ ser. B, 5:3 (1930) 275.

*Carex Wrightii* (non DEWEY) FRANCH. in Bull. Soc. Philom. Paris, 8:7 (1895) 47.

Hab.: m. Niitaka (J. OHWI ns. 3694, 3736), inter m. Taihasenzan et m. Tsugitaka (K. KOJIMA in 1933). Haec planta est ad Floram Formosae nova!

42) *Carex phacota* SPR. var. *shichiseitensis* OHWI comb. nov.

*Carex shichiseitensis* HAYATA Icon. Pl. Formos. 10 (1921) 58.

Hab.: m. Shichisei(ton)zan prope Taihoku (Y. SHIMADA n. 4418), m. Taiheizan (J. OHWI ns. 2406, 2487). Haec planta *C. phacotae* SPR. nimis affinis est.

43) *Carex phaeopoda* OHWI in Acta Phytot. et Geobot. 2 (1933) 159.

Hab.: m. Taiheizan (J. OHWI n. 2351), m. Rarasan in Taihokushu (J. OHWI n. 1000).

44) *Carex pocilliformis* BOOTT Ill. Carex 4 (1867) 175, t. 593.

*Carex tristachya* var. *pocilliformis* KÜKENTH. Cyper. Caric. (1909) 473; HAYATA Icon. Pl. Formos. 6 (1916) 125.



Hab.: Taitum (U. FAURIE n. 820), Okaseki (U. FAURIE n. 26), m. Gakoki (Y. SHIMADA n. 4420), m. Taiheizan (J. OHWI n. 2314; N. FUKUYAMA ns. 4060, 4069), m. Arisan (J. OHWI n. 3440), m. Shichiseizan (J. OHWI ns. 51, 2026, 2029), inter Chakon et Rarasan in Taihokushu (J. OHWI n. 897), ins. Sharyoto prope Kelung (J. OHWI n. 158), Piananambu (N. FUKUYAMA n. 4076), Nokogoe (J. OHWI n. 3141), m. Daibusan (J. OHWI n. 1811).

45) *Carex pseudo-arenicola* HAYATA Icon. Pl. Formos. 6 (1916) 118, f. 35 f-j.

§ *Multiflorae*. Spiculis numerosis caput oblongum vel breviter ovato-cylindricum densum 2-4 cm longum formantibus, bracteis inferioribus 1-2 subfoliaceis vel setaceis quam capite longioribus brevioribusve, squamis late ovatis subacutis vel mucronulatis pallidibus, lateribus pallide fulvo-suffusis vel maculatis, margine late albo-scariosis, dorso viridi uninerviis, utriculis squamas superantibus oblique patentibus conico-ovatis plano-convexis stramineis 4-5 mm longis glabris membranaceis, utrinque nervis brunneis pluribus percursis, margine extenuato viridulo superne denticulato-scabris, basi contracta sessilibus, apice subito attenuatis in rostrum subbreve rectum complanatum ore hyalino bidentulum, nuce utriculorum basi non spongiosum perlaxe implente orbiculato-ovata plano-convexa 1.3 mm longa lutea, stylo recto tenui basi aequali, stigmatibus 2 tenuibus mediocriter longis persistentibus. —Species e grege *C. nubigenae* D. DON.

Hab.: m. Taiheizan (J. OHWI n. 2338; N. FUKUYAMA n. 4063; T. SUZUKI n. 7330), m. Taihasenzan (N. FUKUYAMA), m. Niitaka (J. OHWI n. 2887), m. Arisan (J. OHWI no. 3633).

46) *Carex pumila* THUNB. Fl. Japon. (1784) 39; SCHK. Riedgr. 2 (1806) 82, t. Yy, f. 112; MATSUM. et HAYATA Enum. Pl. Formos. (1906) 496; HAYATA Icon. Pl. Formos. 6 (1916) 131.

Hab.: ins. Sharyoto (S. NAGASAWA), Tamsui (U. FAURIE n. 825; J. OHWI n. 147), Goryu in Shinchikushu (Y. SHIMADA n. 667).

47) *Carex purpureo-tincta* OHWI in Acta Phytotax. et Geobot. 2 (1933) 159.

Hab.: Karapao in Tarokokyo (J. OHWI ns. 1172, 1228).

48) *Carex remotiflora* HAYATA Icon. Pl. Formos. 10 (1921) 68, f. 45.

§ *Debiles*. Squamis oblongis pallidis vel fulvo-suffusis margine late albo-hyalinis, apice obtusissimis, dorso viridi inferne trinerviis, superne sub apice enerviis, utriculis quam squamis plus duplo longioribus erectis

oblongo-lanceolatis 6 mm longis membranaceis viridulis lucidulis glabris trigonis, praeter carinas enerviis, basi cuneatis, apice subsensim attenuatis in rostrum longum (fere 3 mm) lineare rectum laeve ore hyalino oblique sectum demum bidentulum, nuce arcte inclusa oblongo-obovata trigona 2.5 mm longa, facie inferne saepius concava, stylo recto tenui basi vix incrassato, stigmatibus 3 breviter exsertis. — Species ex grege *C. fusiformis* NEES.

Hab.: m. Arisan (U. FAURIE n. 20; J. OHWI n. 3433), inter Kyanrawa et Shikikun in Taihokushu (J. OHWI n. 2486), inter Taiheizan et Kyanrawa in Taihokushu (J. OHWI n. 2374), m. Daibu in Takaoshu (J. OHWI n. 1900), Nokogoe (J. OHWI n. 3177), m. Niitaka (J. OHWI n. 3724), Togano in Taihokushu (N. FUKUYAMA n. 4062), Mururoahu in in Taihokushu (T. SUZUKI n. 7302).

49) *Carex Rochebruni* FRANCH. et SAVAT. var. *remotispicula* OHWI in Mem. Coll. Sci., Kyoto Imp. Univ. ser. B, 6:5 (1931) 258.

*Carex remotispicula* HAYATA Icon. Pl. Formos. 10 (1921) 57, f. 32.

Hab.: m. Arisan (U. FAURIE n. 17; J. OHWI n. 3401), Pianan-ambu (N. FUKUYAMA n. 4057), inter Pianan-ambu et Shikayosha in Taichushu (J. OHWI n. 2762), Chippongoe (J. OHWI n. 1466), m. Taiheizan in Taihokushu (J. OHWI n. 2243).

50) *Carex satsumensis* FRANCH. et SAVAT. Enum. Pl. Japon. 2 (1879) 136 et 558.

*Carex satsumensis* varr. *longiculma* et *Nakaii* HAYATA Icon. Pl. Formos. 6 (1916) 120 et 121, t. 17 et f. 35 a-e.

*Carex nikoensis* varr. *longiculma* et *Nakaii* MASAM. in Journ. Soc. Trop. Agric. Taihoku, 2 (1930) 49 et 50.

Hab.: m. Taiheizan in Taihokushu (N. FUKUYAMA n. 4064; J. OHWI ns. 2311, 2340, 2432), Nokogoe (J. OHWI n. 3150), inter Hattsukan et Rakuraku in Taichushu (J. OHWI n. 3861), inter Hattsukan et Minami in Takaoshu (J. OHWI n. 3750).

51) *Carex scabrifolia* STEUD. Synops. Glum. 2 (1855) 237; KÜENTH. Cyper. Caric. (1909) 737.

Hab.: Yushako prope Tamsui (S. SASAKI! in Governm. Hb., Taihoku). Nova ad Floram Formosae!

52) *Carex Shimadai* HAYATA Mater. Fl. Formosa (1911) 396 (incl. var. *longibracteata* HAYATA), et Icon. Pl. Formos. 6 (1916) 127, f. 39 a-e.

§ *Ferrugineae*. Bracteis inferioribus longe vaginantibus breviter laminiferis, vaginis tubulosis viridibus vel apice basique interdum brunnescentibus, squamis masculis badiis indistincte ciliolatis, femineis ovatis acuminatis vel acutis fulvis, margine vix albohyalino superne indistincte ciliolatis, utriculis quam squamis subduplo longioribus suberectis, sursum saepe leviter excurvis, oblongo-oblongeolatis compresse trigonis 5-6 mm longis hirtulis elevato-multi-costulatis, margine acuto superne hispidulis, basi sensim attenuatis, apice sensim contractis in rostrum breviusculum complanatum ore hyalino bidentatum, nuce subarcte explente anguste oblonga cum stipite (1 mm longo) 3 mm longa compresse trigona, stylo recto tenui basi subincrassato, stigmatibus 3 breviter exsertis.—Species quasi media *C. Warburgianam* KÜKENTH. et inter *C. Makinoensem* FRANCH.

Hab.: m. Shichiseizan (J. OHWI ns. 24, 28), Agyoku in Taihokushu (J. OHWI n. 588), Kelung (U. FAURIE n. 15), inter Urai et Shinten prope Taihoku (S. KITAMURA ns. 480, 482).

(53) *Carex sociata* BOOTT in A. GRAY, Bot. Jap. (1859) 420 et Ill. Carex 4 (1867) 200; C. B. CLARKE in Journ. Linn. Soc. 36 (1904) 311; MATSUM. Ind. Pl. Japon. 2: 1 (1905) 133.

*Carex chinensis* (vix RETZ.) MATSUM. et HAYATA Enum. Pl. Formos. (1906) 4194; HAYATA Icon. Pl. Formos. 6 (1916) 131.

*Carex atronucula* HAYATA Mater. Fl. Formos. (1911) 379.

*Carex uraiensis* HAYATA Icon. Pl. Formos. 10 (1921) 60, f. 35.

Hab.: Okaseki (U. FAURIE n. 27), Urai (U. FAURIE ns. 10, 30), m. Arisan (U. FAURIE ns. 29, 32), ? Bunkiko (U. FAURIE n. 35), m. Kwan-nonsan (T. ITO), Kelung (T. ITO; S. KITAMURA et T. HOSOKAWA n. 2561), Taitum (U. FAURIE n. 824), Mabukutsu (Y. SHIMADA n. 4421), Baibara (M. TATEWAKI), Tarokokyo (S. KITAMURA; J. OHWI n. 1222), m. Shichiseizan (J. OHWI n. 13), prope Taihoku (J. OHWI n. 119), ins. Sharyoto (J. OHWI n. 161), Koko in Taihokushu (T. SUZUKI n. 8397), Daijurin (J. OHWI n. 433), inter Shikikun et Pianan-ambu (J. OHWI n. 2736), Nokogoe (J. OHWI n. 3000), Chippongoe (J. OHWI ns. 1392, 1395), inter Agyoku et Urai (J. OHWI n. 718), Agyoku (J. OHWI n. 572), m. Daibusan (J. OHWI n. 1714).

54) *Carex subtransversa* C. B. CLARKE in Philipp. Journ. Sci. 2 (1907) Bot. 108 et in Kew Bull. Add. ser. 8 (1908) 92; KÜKENTH. in Philipp. Journ. Sci. 6 (1911) Bot. 63.

*Carex Kawakamii* HAYATA Mater. Fl. Formos. (1911) 385 et Icon. Pl. Formos. 6 (1916) 129, f. 41 e-h.

*Carex pseudo-japonica* (non C. B. CLARKE) HAYATA ll. cc. 392 et 129, f. 41 a-d.

*Carex Hayatana* HONDA in Bot. Mag. Tokyo 43 (1929) 191.

Hab.: m. Taiheizan (N. FUKUYAMA ns. 4061, 4065, 5075; T. SUZUKI ns. 7077, 7220; J. OHWI ns. 2289, 2375, 2380), m. Niitaka (J. OHWI n. 3743), Nokogoe (J. OHWI ns. 3178, 3262), m. Kiraishu-nampo (N. FUKUYAMA), inter Shikikun et Pianan-ambu (J. OHWI n. 2692), Karapao in Tarokokyo (J. OHWI n. 1243), Chippongoe (J. OHWI n. 1397), m. Arisan (U. FAURIE n. 24; J. OHWI n. 3435), Bunkiko (U. FAURIE n. 13), inter Matsuyama et Aderu in Takaoshu (J. OHWI n. 1540), inter Chakon et Rarasan (J. OHWI n. 891), m. Taihasenzan in Shinchikushu (N. FUKUYAMA).

55) *Carex taiheiensis* HAYATA Icon. Pl. Formos. 10 (1921) 59.

§ *Tumidae*. Spiculis lateralibus femineis densi-multifloris erectis ca. 3 mm latis, bracteis inferioribus foliaceis viridibus basi breviter vaginantibus, squamis masculis ex apice truncato aristatis, femineis anguste oblongis pallidis, apice obtusis, e dorso lato tricostato cuspidatis, utriculis squamas (cum cuspidate) subsuperantibus erecto-patentibus late ellipticis 2.5-3 mm longis obtuse trigonis olivaceo-viridibus opacis dense papillosohirtis membranaceis plurinervosis, basi contracta breviter stipitatis, apice contractis in rostrum cylindricum rectum subbreve ore hyalino oblique sectum demum bidentulum, nuce arcte nidulante late ovata trigona 1.5 mm longa sessili, stylo brevi recto basi subincrassato, stigmatibus 3 tenuibus breviter exsertis. —Species e grege *C. ischnostachyae* STEUD.

Hab.: inter Doba et Taiheizan in Taihokushu (J. OHWI n. 2195), inter Shikikun et Pianan-ambu (J. OHWI n. 2744).

56) *Carex tatsutakensis* HAYATA Icon. Pl. Formos. 6 (1916) 133, f. 45.

*Carex taihokuensis* HAYATA l. c. 10 (1921) 70.

§ *Rhomboidales*. Squamis femineis pallidis vel pallescentibus lineari-oblongis obtusis, e dorso viridi trinervi breviter aristatis vel cuspidatis, utriculis quam squamis subduplo longioribus 6-7 mm longis oblique erectis obovatis acute trigonis glabris tenuiter plurinervosis, basi cuneato-attenuatis, apice in rostrum sublongum cylindricum parce scaberulum ore hyalino bidentatum, nuce arcte inclusa late obovata acute trigona 3.5 mm longa, basi breviter oblique stipitata, apice contracta, stylo recto brevi basi incrassato, stigmatibus 3 tenuibus



mediocriter longis.—Maxime affinis *C. macrandrolepidi* LÉVEILLÉ, a qua tamen squamis femineis lineari-oblongis nec ovatis non truncatis, utriculis fere glabris differt.

Hab.: inter Chakon et Rahau in Taihokushu (J. OHWI n. 774), inter Matsuyama et Aderu in Takaoshu (J. OHWI n. 1527), Agyoku (J. OHWI ns. 570, 617), inter Chippon et Miharashi in Taitocho (J. OHWI n. 1388), Urai (U. FAURIE n. 12), m. Arisan (U. FAURIE n. 19), Taihoku (U. FAURIE), Bunkiko (U. FAURIE n. 227).

57) *Carex trichosperma* OHWI sp. nov.

§ *Mitratae*. Rhizoma caespitosum estoloniferum abbreviatum, ad collum parce brunneo-fibrillosum, culmo gracili trigono laevi erecto 20–30 cm alto, foliis quam culmo subbrevioribus laete viridibus coriaceis 3–5 mm latis planis, apice sensim angustatis acuminatis, supra obsolete bicostatis, subtus elevato-unicostatis, costis marginibusque scaberulis, vaginis fusco-brunneis subintegris, spiculis 3–5 erectis, terminali mascula lineari-lanceolata ca. 1 cm longa 1–1.5 mm lata pedunculata, reliquis femineis breviter cylindricis sublaxe plurifloris 15–20 mm longis 2.5–3 mm latis, praeter summam quam mascula aequialtam vel contiguam remotis, omnibus plus minus exserte pedunculatis, ima interdum subradicali, pedunculis laevibus, bractearum vaginis 7–12 mm longis laxiusculis virentibus, ore antice scariosis, apice lamina setacea 2–8 mm longa praeditis, squamis masculis pallide stramineis vel pallescentibus trinerviis evanescente plurinervulosis, apice rotundato abrupte acutis, femineis ellipticis pallidis vel pallide stramineis evanescente plurinervulosis, dorso viridi trinerviis, apice truncato-rotundato mucronulatis, utriculis squamas superantibus suberectis 3.5–4 mm longis obovato-fusiformibus membranaceis pallide viridibus multinervosis pilosulis obtuse trigonis, basi subabrupte attenuatis in stipitem longum crassum glabrum, apice contractis rostratis, rostro brevi conico recto concolori ore bidentulo, nuce arcte inclusa trigona, facie inferne plana, cum disco depresso albedo 1/3 mm lato subsessili 2 mm longa, stylo brevi basi incrassato, stigmatibus 3 mediocriter longis.—Species e grege *C. tristachyae* THUNB.

Hab.: m. Arisan (J. OHWI n. 3919–Typus), ibid. (U. FAURIE n. 33).

58) *Carex urelytra* OHWI sp. nov.

§ *Frigidae*. Rhizoma dense caespitosum estoloniferum, collo fibris brunneo-spadiceis comose cincto, culmo pedali et ultra, erecto subtenui



triquetro laeviusculo, superne nutante, basi conferte foliato, foliis culmum aequantibus planis rigidulis stramineo-viridibus 3-5 mm latis, apice sensim acuminatis, marginibus crebre scabris, utrinque imprimis supra scabris, subtus elevato-, supra impresso-unicostatis, utrinque striatis, vaginis brunneis, in fibris parallelis serius solutis, spiculis pluribus saepius geminis ternisve androgynis (terminali longius, lateralibus breviter vel brevissime masculis) cylindricis inaequaliter pedunculatis nutantibus 2-4 cm longis ad 4 mm latis multi-densi-floris, bracteis inferioribus subfoliaceis, basi vaginantibus, superioribus apice breviter setaceis, squamis conformibus lanceolatis castaneis lucidulis, margine superne late scarioso-hyalinis non ciliatis, e dorso unicostato concolori super apicem acutum in aristam tenuem 1-3 mm longam scaberulam plerumque recurvam abeuntibus, utriculis quam squama (absque arista) duplo longioribus adpressis lanceolatis flavo-viridibus plerumque ferrugineo-suffusis 6-7 mm longis compressis tenuiter membranaceis obsolete nervosis sparsim pilosulis, margine acuto pilis patenti-recurvis ciliatis, basi contracta sessilibus, apice sensim attenuatis in rostrum longum complanatum ore hyalino profunde bidentatum, cruribus subulato-lanceolatis rectis fere 1 mm longis, nuce utriculum apice basique longe vacuum laxiuscule implente oblonga compresse trigona conspicue stipitata 2.5 mm longa, stylo tenui incluso basi aequali, stigmatibus 3 tenuibus 5-6 mm longis persistentibus.—Species e grege *C. longicuspidis* BÖCKLR. A *C. longistipiti* HAYATA, squamarum forma diversa est.

Hab.: Nokogoe in Taichushu (J. OHWI n. 3351-Typus), Chipongoe in Taitocho (J. OHWI n. 1409).

59) *Carex Warburgiana* KÜKENTH. in Bull. Herb. Boiss. 2:5 (1905) 1162 et Cyper. Caric. (1909) 564.

Hab.: Kuanania (WARBURG! in Herb. Berol.).

60) *Carex Zollingeri* KUNZE ex STEUD. Synops. Glum. 2 (1855) 221.

*Carex japonica* var. *chlorostachys* KÜKENTH. ex MATSUM. Ind. Pl. Japon. 2:1 (1905) 116; KÜKENTH. Cyper. Caric. (1909) 620 ex pte.

*Carex Sasakii* HAYATA Mater. Fl. Formos. (1911) 395 et Icon. Pl. Formos. 6 (1916) 131, f. 42 a-e.

Hab.: inter Asahi et Riyohen in Taihokushu (T. SUZUKI n. 8871), inter Aderu et Shimo-paiwan in Takaoshu (J. OHWI n. 1627), in m. Taiheizan (J. OHWI n. 2216), Tarokokyo (J. OHWI n. 1213), m. Shakarotaisan in Shinchikushu (N. FUKUYAMA), Bunkiko (U. FAURIE n. 9).

*Species non satis notae*

1) *Carex longispica* HAYATA Mater. Flor. Formos. (1911) 386 (ut *longispicata*) et Icon. Pl. Formos. 6 (1916) 127 non BÖCKLR.

Hab.: m. Kentozan in Giran (T. KAWAKAMI et U. MORI! specimina nimis imperfecta in Hb. Tokyo Imp. Univ. et in Governm. Hb. Taihoku servata).

2) *Carex transalpina* HAYATA Mater. Flor. Formos. (1911) 398 et Icon. Pl. Formos. 6 (1916) 125.

Hab.: in m. Morrison 9000 ped. (T. KAWAKAMI et U. MORI! in Hb. Tokyo Imp. Univ.). Est *C. daibuensis* HAYATA?

BOTANICAL INSTITUTE, FACULTY OF SCIENCE,  
KYOTO IMPERIAL UNIVERSITY, KYOTO.

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# Cyto-genetical studies on *Oryza sativa* L.

## II. Spontaneous autotriploid mutants in *Oryza sativa* L.<sup>(1)</sup>

By Toshitaro MORINAGA and Eiji FUKUSHIMA

With 57 text-figures

(Received July 13, 1934)

The triploid plant of rice<sup>(2)</sup> was described first in 1932 by NAKAMORI(4). In that year, the authors, in order to obtain the triploid, selected out in their breeding farm of rice several sterile but exceptionally vigorous individuals. Cytological investigations which followed made it clear that one of those individuals possessed 36 chromosomes in its root-tip cells, while the others possessed 24 or the normal number of chromosomes. Thus one individual which was found in a  $F_3$  line of Mitsuryûtô ♂  $\times$  Kinenmoti ♂ was demonstrated as a triploid. Other misselected vigorous and sterile individuals were in all probability the natural hybrids between *japonica* and *indica* type varieties.<sup>(3)</sup>

In 1933, to get rid of such confusion of sterile diploids caused by hybridization, the authors looked for the triploid chiefly in common rice fields. In such fields, occasional sterile diploids were also met with, but they were distinguished easily from the triploid by the normal size of their leaves or spikelets. The authors selected in that year more than 150 individuals, and cytological examinations proved that the selection made by appearances was, under such precautions, highly reliable. The root-tip cells were examined for about 50 selected individuals of which 45 possessed the triploid

(1) Contributions from the Institute of Agronomy, Kyushu Imperial University, No. 55.

(2) Assuming the normal rice plant with 24 somatic chromosomes as diploid, the plant with 36 somatic chromosomes is taken as a triploid.

(3) Some *indica* type varieties are notably more vigorous, and produce much larger spikelets than the *japonica* type varieties. The hybrid between a *japonica* variety and such an *indica* variety resembles in several respects the triploid of the *japonica* variety.

chromosome complement, and the individuals disproved to be triploids were only such as had been doubted for some reason or other. Now out of the remaining individuals the authors could reselect with confidence, though by appearances, 107 more individuals as triploids.



Fig. 1 a, b, c. The ears of Mituryûtô, Kinenmôti and the triploid.  
1 a. Kinenmôti; 1 b. the triploid; 1 c. Mituryûtô.

As compared with the diploid, the triploid individual is notably more vigorous. It has broader leaves and stouter tillers, and produces larger ears and spikelets. The length and width of the spikelets of the first triploid found in the  $F_3$  line of Mitsuryûtô ♂ × Kinenmoti ♀ were on the average 8.13 mm and 3.76 mm, while those values were 6.74 mm and 3.62 mm for Mitsuryûtô, and 7.40 mm and 3.37 mm for Kinenmoti (Fig. 1). The triploid tillers are less in number than the diploid.

The fertility of the triploid is very low. Nineteen triploids out of the 45 determined directly produced in total 53 ears. They set altogether 3617 spikelets, and 57 seeds were obtained, the percentage of the fertile spikelets being 1.58%. One hundred and seven triploids, determined indirectly, produced in total 323 ears, of which the total number of spikelets was 21796, and that of seeds 480, the percentage of the fertile spikelets being calculated as 2.20%. The first triploid plant found in 1932 produced 6 seeds (0.65% fertility) in that year, and 27.92% of the spikelets contained parthenocarpic ovaries. Out of those 6 seeds 2 germinated. One plant showed normal appearance, while the other was markedly dwarf, producing rolled leaves. The latter after all did not shoot the ear. The first triploid was propagated vegetatively to 33 individuals in the next year. The results of artificial cross experiments made between these and normal varieties are shown in the following table.

Results of artificial cross between diploid  
and triploid plants

	Triploid × Diploid	Diploid × Triploid
Perfect seeds	27	15
Parthenocarpic ovaries	19	0
Perfectly sterile spikelets	2504	2281
Total spikelets used	2550	2296
Fertility %	1.06	0.65

The hybrid is more easily obtainable when the triploid is chosen as the female parent.



## Cytological observations

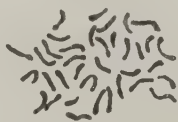
### Materials and methods

To study the somatic chromosomes, root-tips fixed with FLEMMING's fixative were sectioned by the paraffin method, and stained with iron-alum-haematoxylin. Micro- and megasporogenesis were studied exclusively on the triploid found in 1932. The materials were fixed with BOUIN's solution, and the later treatments were essentially the same as those for the root-tip.

### Observations on the somatic Chromosomes



2



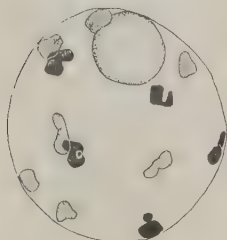
3

Figs. 2 and 3. Somatic chromosomes in the root-tip cells of triploid *Oryza sativa*.  
×2670

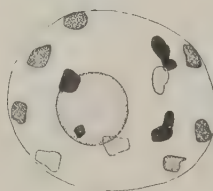
As already mentioned, 45 plants were determined to be triploid by the examination of the somatic chromosomes. Figs. 2 and 3 show 36 small rod-shaped chromosomes found on the metaphasic plate of the triploid.

### Microsporogenesis

*Heterotypic division:* The history of the chromosome complement was followed chiefly from the diaphase of the first meiotic division. At diakinesis the 36 chromosomes usually arrange in 12 groups, no doubt of 3 each. In consequence of the-imperfect associa-



4



5



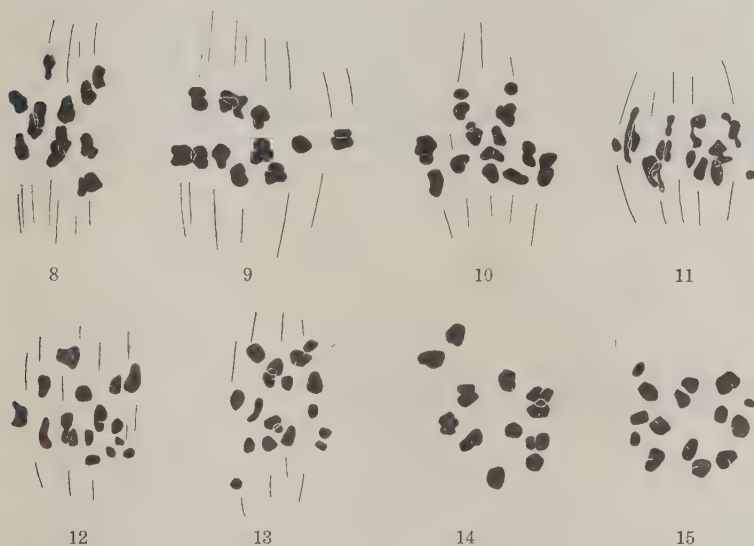
6

Figs. 4-6. Diakinetic nuclei of triploid *Oryza sativa*. ×2670

tion of the homologues, however, the nucleus with more than 12 groups were not infrequently met with (Figs. 4, 5 and 6). The synaptic condition of the diakinetid chromosomes, whether they were trivalent, bivalent or univalent, was clearly interpreted by their shape only for some chromosomes within a nucleus. Figs. 7a and 7b illustrate the appearance of some trivalent chromosomes. The



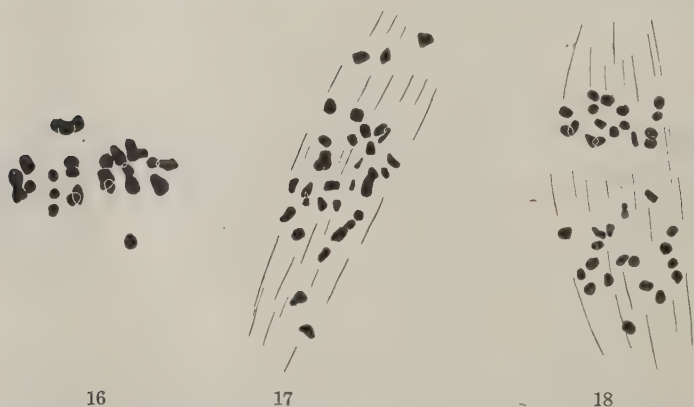
Figs. 7a and 7b. 7a. Appearance of trivalents in early diakinesis; 7b. appearance of trivalents in late diakinesis.  $\times 2670$



Figs. 8-13. Side views of the heterotypic metaphase of triploid *Oryza sativa*; 8 and 9. with 12 trivalents; 10. with 15 chromosomes, 3 of which are univalent; 11, 12 and 13. with 15, 16 and 18 chromosomes respectively.  $\times 2670$

Figs. 14 and 15. Polar views of the heterotypic metaphase of triploid *Oryza sativa*; 14. with 12 trivalents, 2 of which are slightly displaced; 15. with 15 chromosomes, 3 of which are univalent.  $\times 2670$

prophasic nucleus of the triploid very often contains two large nucleoli. In the heterotypic metaphase usually 12 or slightly more chromosomes are counted. The largest number of the metaphasic chromosomes ever observed was 18. Figs. 8, 9, 10, 11, 12 and 13 are the side views of the metaphasic plate. In Figs. 8 and 9, 12 trivalent chromosomes are counted. Most chromosomes in the figures show a conspicuous appearance of trivalent, while a few of those, owing to the compact association of the homologues, take simple or bivalent-like form. Fig. 10 shows 15 chromosomes, and 3 univalents, 2 of which are situated close to their homologous bivalents, are easily noticeable. Figs. 11 and 12 represent respectively 15 and 16 chromosomes. In Fig. 13, there are 18 chromosomes of which 6 small round ones slightly out of the equator are taken as univalents. Figs. 14 and 15 are the metaphasic plates in the polar views. In the former plate there are 12 trivalents, while in the latter there are 15 chromosomes, of which 3 are pointed out as univalents. In the heterotypic anaphase, the trivalent chromosomes disjoin, as a general rule, to the 3 components, and one travels to one pole and the other two to the opposite. Fig. 16 is an early anaphasic spindle in its side view: Some trivalents in the figure still retain their components very compactly, while the others have disjoined already to 3 univa-



Figs. 16-18. Side views of the heterotypic anaphase of triploid *Oryza sativa*; 16. early anaphase showing the disjunction of a few trivalents; 17. with disjoined univalents and 3 trivalents intact; 18. disjunction has been completed for all chromosomes.  $\times 2670$

lents or to 1 bivalent and 1 univalent. In Fig. 17, the disjunction of the homologues has been completed for all chromosomes except those 3 trivalents found near the equator. The cell depicted in Fig. 18 no longer contains any multivalent chromosome, and about 36 univalents are counted in the two anaphasic groups. Fig. 19

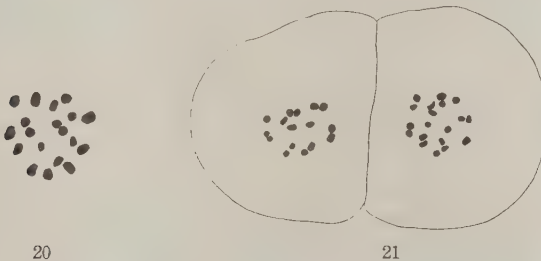


Fig. 19. The mode of disjunction of the trivalent chromosomes.  $\times 2670$

illustrates the mode of disjunction of trivalent chromosomes. In late anaphase a few univalents often lag near the equatorial region. They soon take the dumb-bell shape or split perfectly. The largest

number of such lagging chromosomes observed was 5. The chromosomes which have reached the poles soon reform the daughter nuclei, and the first cytokinesis follows normally.

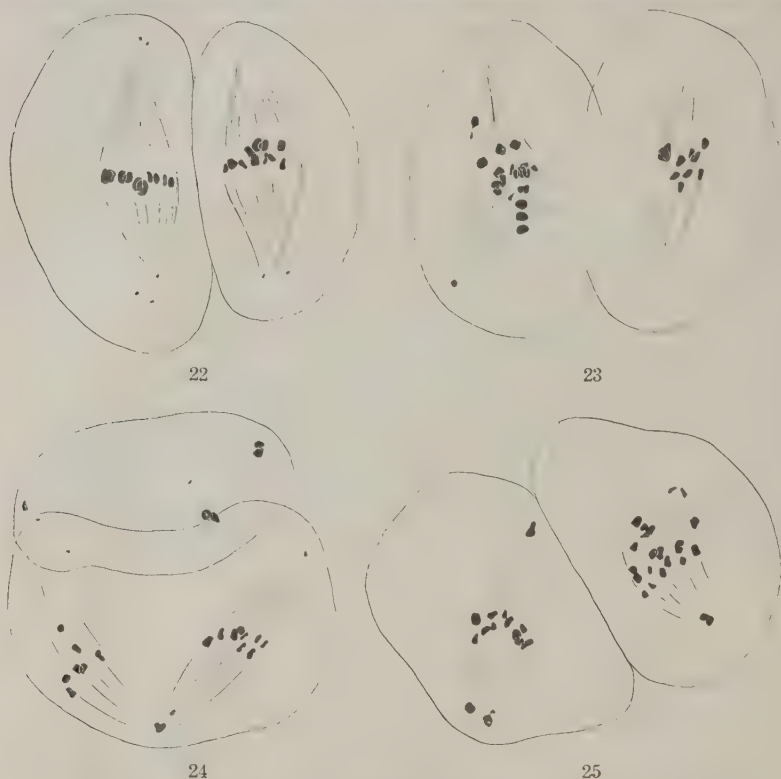
*Homotypic division:* In the homotypic metaphase, as would be expected, 18 or more or less chromosomes are counted in each plate. In most cases the homotypic chromosomes do not disperse so well as they do in the heterotypic plate. Figs. 20, 21 and 22 illustrate the common and normal appearance of the homotypic



Figs. 20 and 21. Common and normal appearance of the homotypic metaphase in polar view. 20,  $\times 2670$ ; 21,  $\times 2000$

metaphase. The second meiotic process proceeds, as a general rule, simultaneously in the two sister sporocytes. Figs. 23, 24 and 25 are exceptional sporocytes with abnormal spindles. One spindle in Fig. 23 is normal, while its sister spindle possesses three poles. In Fig. 25, one of the sister spindles is bent abnormally. One of the secondary sporocytes in Fig. 24 contains no spindle, and the other one contains two spindles having one pole in common. The last case

was no doubt induced by the abnormality in the heterotypic division. A few chromosomes often lag in the anaphase near the equatorial



Figs. 22-25. Regular and irregular homotypic spindles of triploid *Oryza sativa*; 22. regular homotypic spindle; 23-25. irregular homotypic spindles.  $\times 2000$ .

region. The second cytokinesis is carried through normally, and 4 microspores of nearly equal size result, though most of those are unable to develop into normal pollen grains.

### Megasporogenesis

Owing to the nature of the material, the authors could not obtain a satisfactory number of clear figures to give a thorough view of



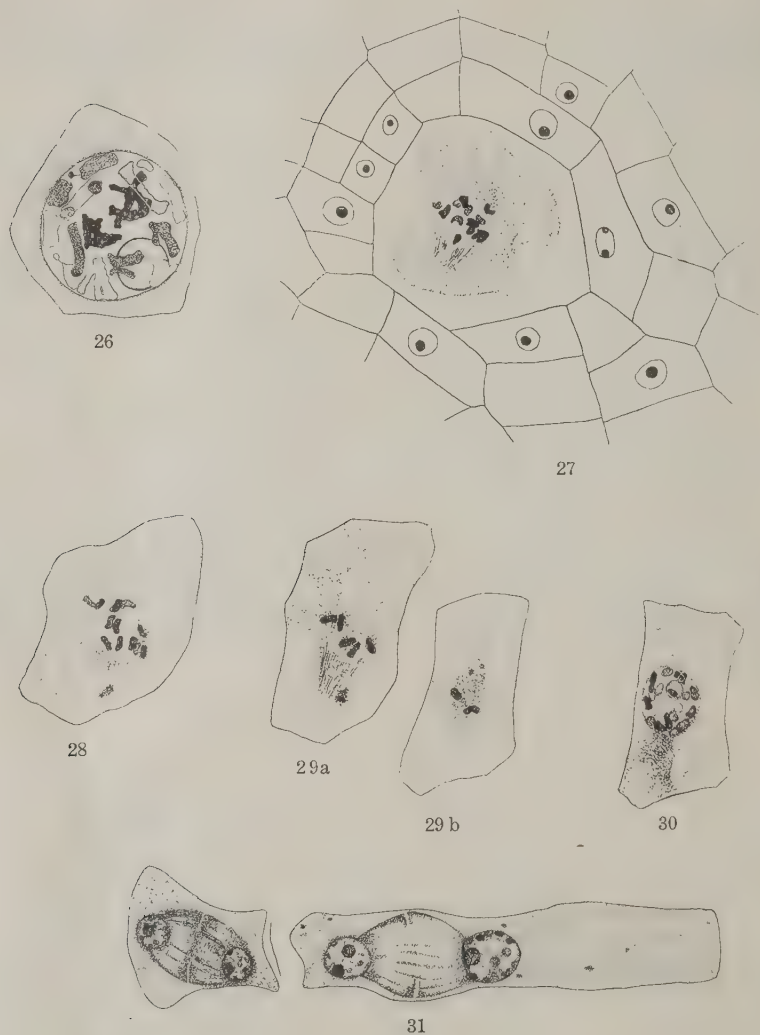
the meiotic divisions. The following descriptions, however, will suffice to show that the divisions in the embryo-sac mother-cell are carried out in essentially the same manner as in the case of the pollen mother-cell.

*Heterotypic division:* Fig. 26 shows a diakinetik nucleus containing 17 chromosomes. Some chromosomes show the nature of conjugation very clearly, but it is entirely indistinct for others. Fig. 27 represents a metaphasic cell in which 13 chromosomes are distributed on the equatorial plate. A photograph of an anaphasic cell with some lagging chromosomes is presented in Fig. 40. Soon after the nuclear division the spindle substance enlarges to its maximum breadth, and the first cytokinesis is started normally (Fig. 41).

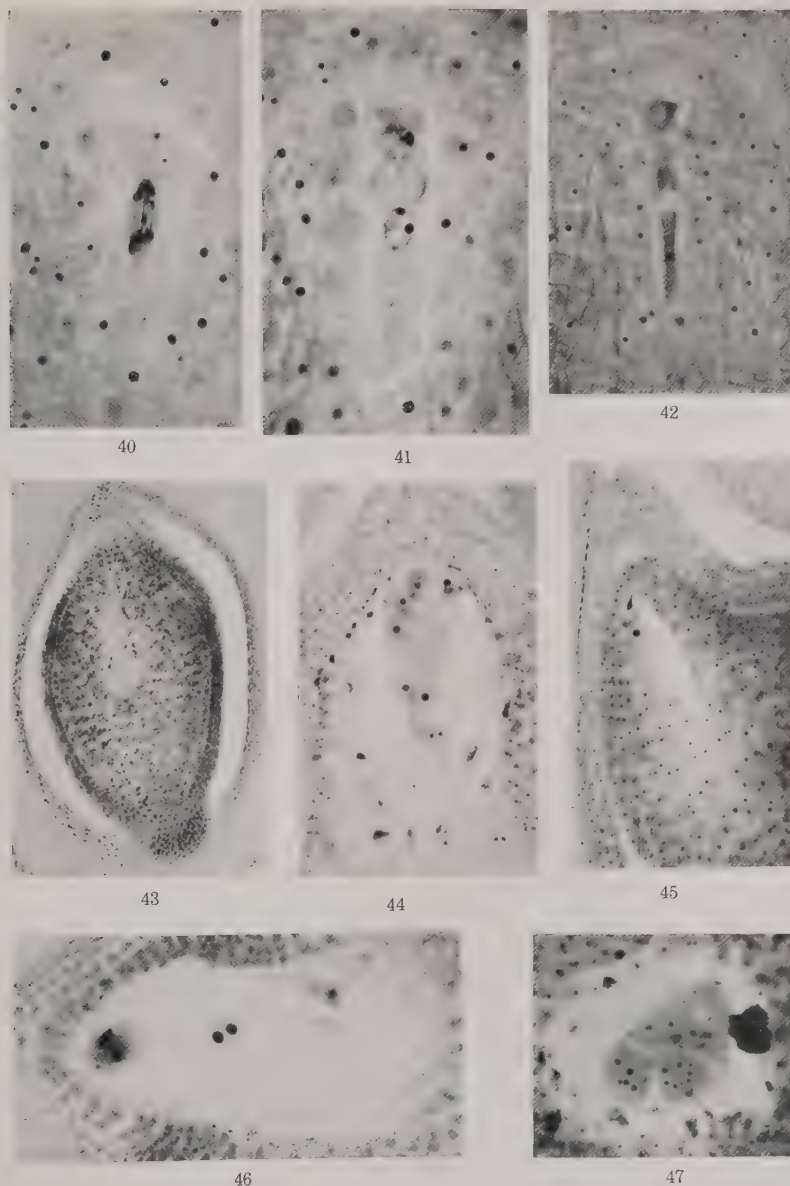
*Homotypic division:* Figs. 28, 29 and 30 represent two sister secondary sporocytes in three sections. Figs. 28 and 29a show the metaphasic spindle of the sporocyte on the micropylar end. Sixteen chromosomes on the equatorial plate do not show any sign of the secondary association. The other sporocyte depicted in Figs. 29b and 30 contains a prophasic nucleus with one nucleolus and about 20 chromosomes. The homotypic nuclear division processes proceed normally, and the secondary cytokinesis is accomplished in a manner similar to the primary one. Fig. 31 represents the sister sporocytes in the homotypic telophase.

### Embryo-sac formation

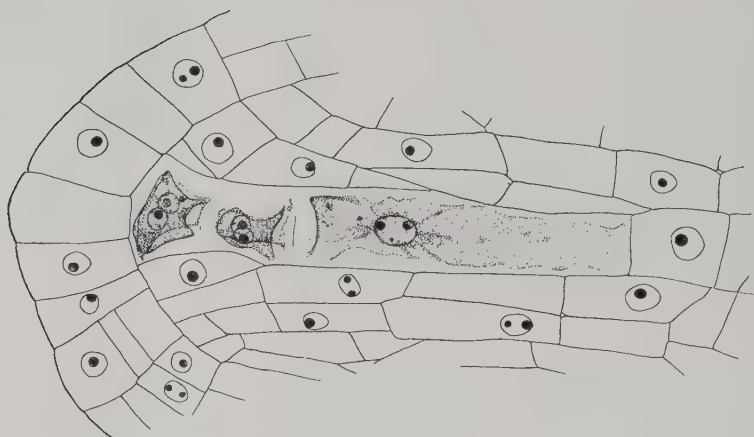
Generally the embryo-sac formation of the triploid plant proceeds in a normal manner. Soon after the reduction divisions, one of the 4 megaspores, the innermost one, starts growth, and its nucleus divides three times successively without cell wall formation. Though the remaining megaspores, as a general rule, soon degenerate, some of those may be divided once before the degeneration process sets in (Fig. 32). Figs. 33, 34 and 46 are the normal embryo-sacs of the triploid plant. They contain one egg cell, two synergid cells and two pole nuclei. The embryo-sac in Fig. 34 is comparatively young, and possesses three primary antipodal cells. They usually divide once or more; thus fully matured embryo-sacs contain supernumerary antipodal cells (Figs. 33 and 38). The nucleus of the antipodal cell also shows a strong tendency to divide, without being accompanied by cell division (Figs. 33 and 37). In a certain



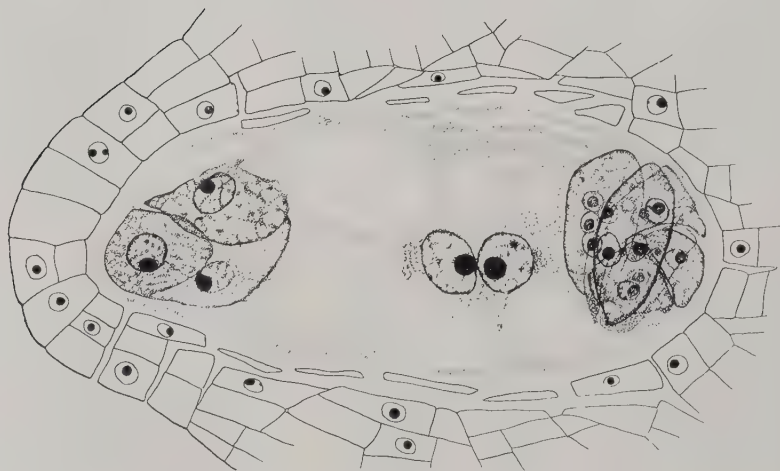
Figs. 26-31. Megasporogenesis in triploid *Oryza sativa*; 26. diakinesis showing 17 chromosomes. ( $\times 2400$ ); 27. heterotypic metaphase. ( $\times 1800$ ); 28-30. two sister secondary sporocytes depicted from 3 sections of an ovule; 28 and 29 a. the sporocyte on the micropylar end of ovule. 16 metaphasic chromosomes inside do not show any secondary association; 29 b and 30. another sporocyte in late prophase. About 20 round chromosomes are observable. ( $\times 2400$ ); 31. homotypic telophase starting second cytokinesis. ( $\times 1800$ )



Figs. 40-47. Photographs of ovules in triploid *Oryza sativa*; 40. EMC in heterotypic anaphase. ( $\times 980$ ); 41. EMC in heterotypic telophase. Cell wall formation is beginning. ( $\times 980$ ); 42. degenerating megaspores. ( $\times 650$ ); 43. general appearance of an ovule showing the trace of degenerated megaspores. ( $\times 145$ ); 44. a part of embryo-sac in eight nuclei stage. Seven young cells or nuclei are observable in the figure. The nucleus in the lowermost cell has been divided. ( $\times 290$ ); 45. an abnormal embryo-sac, containing only one cell. ( $\times 290$ ); 46. a normal embryo-sac. One egg, two synergid cells, two pole nuclei and one antipodal cell are observable in the figure. ( $\times 290$ ); 47. three antipodal cells in normal embryo-sac. Each cell contains a large number of small nuclei. ( $\times 440$ )



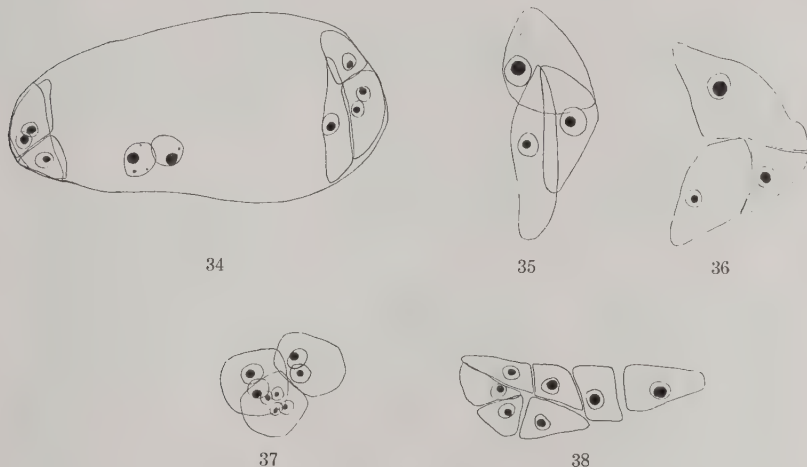
32



33

Figs. 32 and 33. Ovules of triploid *Oryza sativa*; 32. the innermost megaspore has grown to some extent, while the others are degenerating. ( $\times 1200$ ); 33. normal embryo-sac. ( $\times 530$ )

extreme case, the number of nuclei in one antipodal cell reached 17. The division of the antipodal nucleus occurs sometimes fairly early in the stage of sac formation (Fig. 44). Fully matured sacs containing 3 antipodal cells are of rare occurrence (Figs. 35 and 36). In some old antipodal cells with many small nuclei, fusion of nuclei seems occasionally to occur (Figs. 48 and 49).

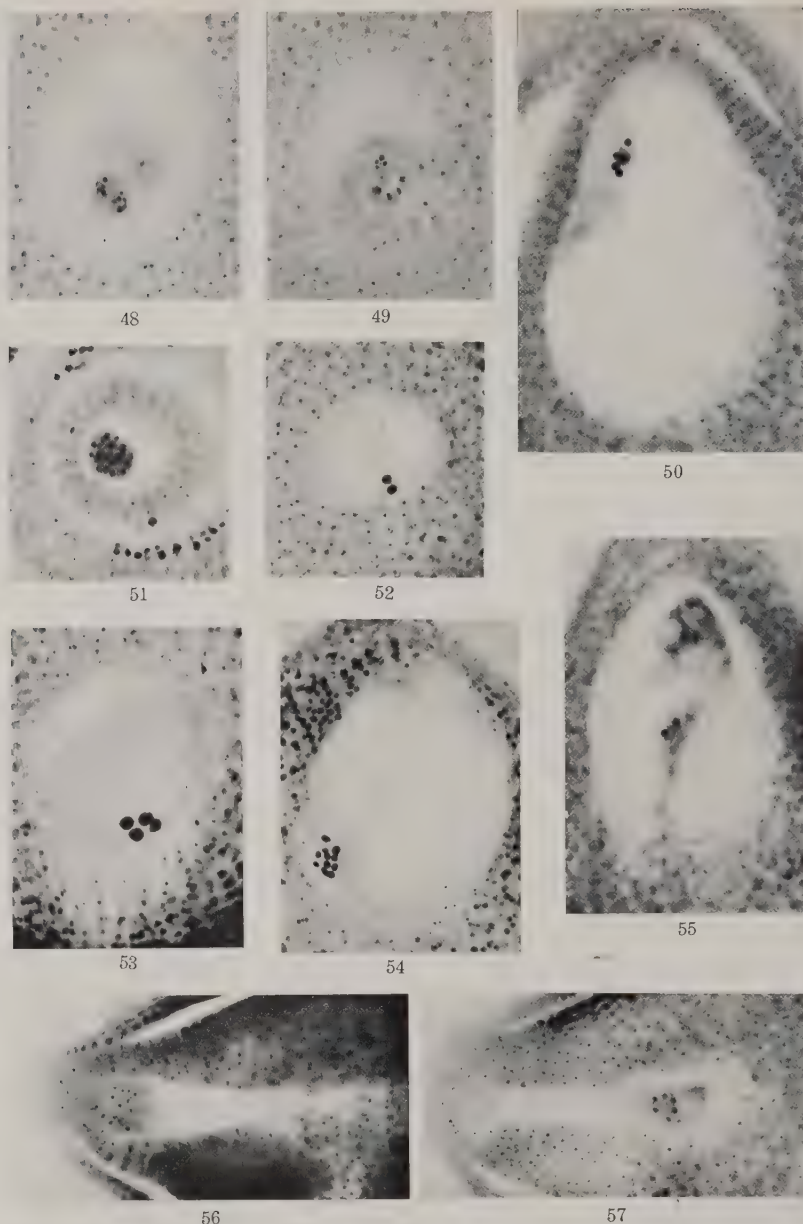


Figs. 34-38. Schematic drawings of embryo-sac and its antipodal cells in triploid *Oryza sativa*; 34. normal embryo-sac in early stage of maturity. ( $\times 530$ ); 35 and 36. antipodal cells depicted from matured embryo-sacs. Three primary ones remain intact. ( $\times 530$ ); 37. three antipodal cells with supernumerary nuclei. ( $\times 530$ ); 38. seven antipodal cells in an embryo-sac. ( $\times 530$ )

The authors examined in total 164 ovaries, of which 108, or 65.9% of the total, contained normal embryo-sacs as above described, and 44 ovaries, or 26.8% of the total, contained abnormal sacs, while in the remaining 12 ovaries, or 7.3% of the total, the megaspore degenerated without showing any further development (Figs. 42 and 43). Some representative cases of the abnormal sacs are as follows:

1. The normal three successive mitoses of the megaspore nucleus do not occur regularly, and the matured embryo-sac which results, lacks some of its apparatuses. The imperfect sac in Fig. 53





Figs. 48-57. Photographs of ovules in triploid *Oryza sativa*; 48 and 49. antipodal cells in two successive sections of a normal embryo-sac. Fusion of nuclei is taking place. ( $\times 290$ ); 50. an abnormal embryo-sac. A group of 8 bare nuclei clings to the wall of sac. ( $\times 290$ ); 51 and 52. two sections of a normal embryo-sac. A young embryo and intact pole nuclei are clearly observable. ( $\times 290$ ); 53. an abnormal embryo-sac containing only 4 large nuclei. ( $\times 290$ ); 54. an abnormal embryo-sac containing only a group of 11 nuclei. ( $\times 290$ ); 55. a part of an abnormal embryo-sac of which the micropylar part is filled up with many small cells, formation of other apparatuses being incomplete. ( $\times 290$ ); 56 and 57. two successive sections of an abnormal embryo-sac which is entirely filled up with a large number of small cells. ( $\times 290$ )

contains, though the sac locule is growing already, only 4 pole nucleus-like nuclei. In most extreme case, only one cell is found in the locule, the megaspore nucleus not being divided at all (Fig. 45).

2. The degeneration sets in soon after three successive mitoses of the megaspore nucleus. Fig. 50 shows a group of 8 bare nuclei observed in a sac which is contained in an ovule growing parthenocarpically.

3. In some embryo-sacs the apparatus differentiates in abnormal ways. One such abnormal sac contained 1 egg, 2 synergids, 4 pole nuclei and 2 other small nuclei but not the antipodal cells.

4. In several ovules, the embryo-sac locule contained a group of bare nuclei, more than 8 in number, which clung to the wall of sac, no other apparatus being formed (Fig. 54).

5. In a few embryo-sacs, the micropylar part of locule was filled up with a group of cell. In the sac shown in Fig. 55, a group of ca. 18 small cells may be observed on the micropylar end, and 5 additional large bare nuclei are scattered in the locule.

6. An ovule is found of which the sac locule is almost filled up with a large number of small cells (Figs. 56 and 57).

Very rarely the authors observed the exclusive development of either embryo or endosperm only in a normally formed embryo-sac. Figs. 39a-f represent 6 successive sections depicted in regular sequence from the micropylar section. The egg cell in the figure remains intact, while the pole nuclei have been divided already producing many endosperm nuclei of normal appearance. Figs. 51 and 52 show a part of another embryo-sac in 2 sections. In this embryo-sac a young embryo is already formed, while the pole nuclei remain intact. It is uncertain whether a single fertilization was effected in these cases, or the development was caused without fertilization at all.

### Parthenocarpic development of the triploid ovary

The ovary of the triploid containing normal or abnormal embryo-sac has a strong tendency to start growth without producing proper seed parts. In a majority of such cases, ovaries are so enlarged as to fill up nearly the whole glume-cavity. Ovaries which lack the embryo sac also show parthenocarpic growth to some extent. The mode of parthenocarpic growth in the triploid ovary is similar to that observed on the haploid rice plant(3).

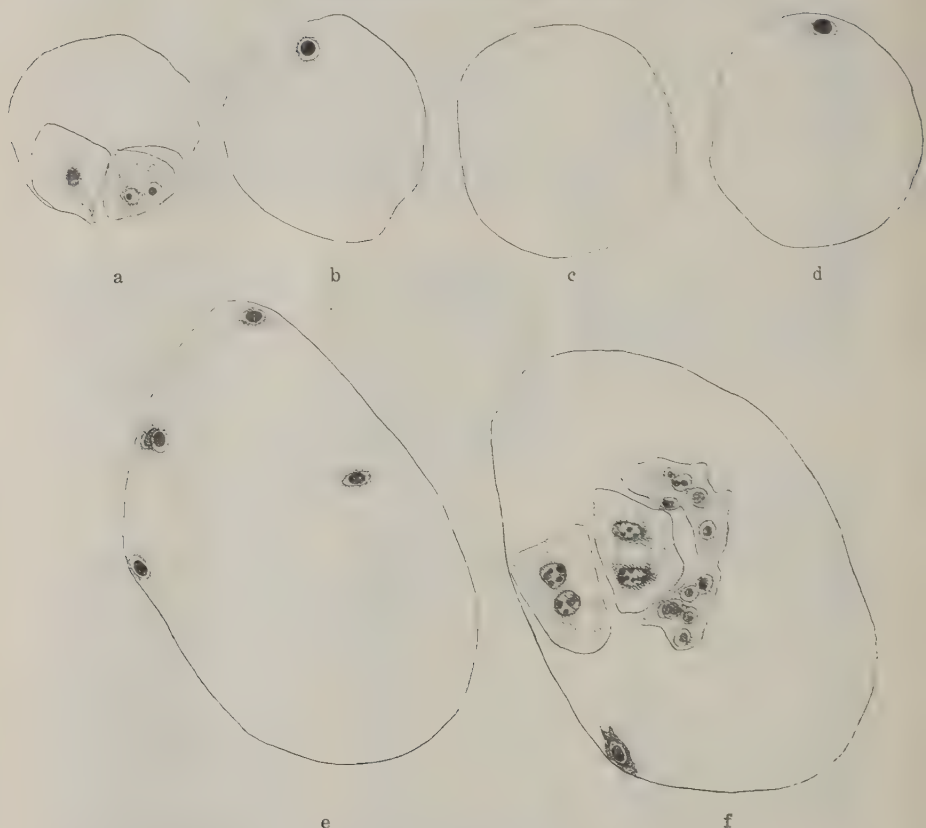


Fig. 39. Schematic drawings of an embryo-sac in triploid *Oryza sativa*; a-f represent six successive sections of the sac. Egg cell remains intact, but the pole nuclei have been divided. ( $\times 530$ )

## Consideration

As already mentioned the authors found in one season more than 150 triploid individuals in common rice fields. According to personal information, Mr. NAKAMORI also found in one year more than 70 triploid plants of rice. It is certainly a remarkable fact to find such a great number of autotriploid plants in a species reproduced sexually. In the Gramineae, the only autotriploid comparable on various points to the present case has been reported in *Zea Mays* (2 and 5). But whether the triploid occurs so often in *Zea* as in

*Oryza sativa* is entirely unknown. How the autotriploid individuals come to exist so often in *Oryza sativa* is an interesting problem still to be solved. Autotriploid has usually been attributed to the union of a haploid gamete with an occasional diploid one. Such might also be the case in *Oryza sativa*. In the rice field, however, not only the triploid, but also haploid and tetraploid mutants appear together though in less frequency (3). Thus another co-ordinate cause for all such chromosomal mutants might be considered. There is no denying the chance of intrusion of double sets of male nuclei into a single embryo-sac (1). In such case there would occur various unusual fusions of nuclei which may be casually related to the formation of triploid, tetraploid, or even of haploid, especially when twin embryos result.

As compared with diploid, the triploid produces broader leaves, larger spikelets and thicker stems in less number. The percentage of the fertile spikelets was in natural condition ca. 2%, and a slightly less than 30% of the spikelets contained parthenocarpic ovaries. These descriptions essentially agree with those given by NAKAMORI (4).

Thirty-six chromosomes in the spontaneous triploid show a strong tendency to make 12 trivalents. Some univalent and bivalent chromosomes observed in diakinesis and in the heterotypic metaphase would indicate very early disjunction of some loose trivalents rather than the entire non-conjunction of the homologues. No tetravalent chromosome was produced. In the heterotypic anaphase, a trivalent disjoins to the three homologues, and 2-1 distribution to the poles seems to be quite regular. In the homotypic metaphase, some chromosomes are situated closely like loose bivalents (Figs. 20 and 21). If so-called secondary association of chromosomes in the homotypic plate of diploid is caused by real homology of chromosomes, the homotypic chromosomes in the triploid would show a tendency to make trivalent-like association, but such is not the case. As the homotypic division is carried out rather regularly, most microspores produced will contain 18, or more or less numerous chromosomes. On the other hand most microspores produced degenerate sooner or later leaving a comparatively small number of well formed pollen-grains. This suggests that the microspores containing about 18 chromosomes are not viable.

The reduction divisions in the megasporocyte are carried through in a manner similar to those in the microsporocyte.

Contrary to the microspores, a considerably high percentage of megaspores thus produced develop into embryo-sacs of normal appearance. Notwithstanding such a high percentage of well formed embryo-sacs, the fertility of the triploid is very low even when normal pollen-grains are applied. Thus it is presumed that most egg cells, even though fertilized with normal gametes, are not able to produce viable zygotes. This idea is corroborated by the fact that the percentage of germination is very low in the seeds of the triploid. When megaspores do not develop into normal gametophytes, there are seen various kinds of malformed embryo-sacs. In some extreme cases, the megaspores degenerate in a fairly early stage without showing any further development. All such developmental differences depend, no doubt, chiefly on the number and nature of the unbalanced excess chromosomes contained by chance in the megaspore nucleus.

### Summary

1. The authors found in 1932 an autotriploid plant in a certain  $F_3$  line of a varietal hybrid Mitsuryûtô ♂ × Kinenmoti ♂. In the next year they found more than 150 triploids chiefly in fields under common cultivation.

2. As compared with the diploid, the triploid plant is notably more vigorous, producing broader leaves, stouter tillers and larger ears and spikelets. The fertility of triploid was, in natural condition, about 2% or less, and the percentage of the parthenocarpic ovaries was slightly less than 30%. The hybrid between the diploid and the triploid was more easily obtainable when the former is taken as the female parent. The percentage of germination of the  $F_1$  seeds was very low.

3. As to the cause of the triploid formation, the union of a haploid gamete with a diploid one is conceivable. But there is no denying the chance of another unusual fertilization which would be caused by the intrusion of more than one set of male nuclei into a single embryo-sac.

4. In diakinesis and the heterotypic metaphase of the pollen mother-cell, most chromosomes appear as trivalents. Some univalent and bivalent chromosomes which appear in those stages would have been caused by a very early disjunction of some loose trivalents. In the heterotypic anaphase, the trivalents disjoin to the three homo-



logues, and usually one travels to one pole and the other two to the opposite one.

5. In the homotypic metaphase, some chromosomes may appear to be closely arranged to each other like loose bivalents, but no trivalent-like association was observed.

6. By the reduction divisions, 4 microspores of nearly equal size are produced, but they can rarely develop into the pollen-grains of normal appearance.

7. The reduction divisions in the embryo-sac mother-cells are carried out in essentially the same manner as in the case of the pollen mother-cells.

8. Out of the 4 megaspores produced, the innermost one develops into the embryo-sac after 3 successive nuclear divisions. Out of 164 ovaries examined, 108 contained normal embryo-sacs, and 44 ovaries contained abnormal ones. In the remaining 12 ovaries, the megaspores degenerated, showing no further development.

9. The authors observed an embryo-sac in which the egg cell remains intact, while the pole nuclei have been divided already producing many endosperm nuclei of normal appearance. Contrary to the case, an embryo-sac with intact pole nuclei and a young embryo was also observed.

PLANT-BREEDING LABORATORY,  
KYUSHU IMPERIAL UNIVERSITY.

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# Phragmidium of Japan

By Naohide HIRATSUKA

With plates III-IV and 6 text-figures

(Received October 3, 1934)

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## Introduction

In his paper, "On the Japanese species of *Phragmidium*" (1910), KASAI (42) recorded sixteen species of *Phragmidium* including *Phragmidium japonicum* DIET. (= *Kuehneola japonica* DIET.) and *Ph. carbonarium* (SCHLECHT.) WINT. (= *Xenodochus carbonarius* SCHLECHT.) from our country. It is now twenty-four years since the publication of KASAI, and during that long period a number of reports concerning the Japanese species of *Phragmidium* has been made by DIETEL, the SYDOWS, TOGASHI, YOSHINAGA, the writer and others. In these reports twelve more species including eight new species have been recorded.

The specimens examined have been collected from different localities of our country, extending from South Saghalien and the Kuriles on the north, to Formosa on the south. The total number of Japanese specimens examined by the writer amounts to more than 600, in which the following twenty-six species are included.

### Section *Euphragmidium*

1. *Phragmidium Rubi-japonici* KASAI
2. *Ph. arcticum* LAGERHEIM
3. *Ph. Rubi-Idaei* (DC.) KARSTEN
4. *Ph. Rubi-Oldhami* TOGASHI et MAKI
5. *Ph. Miyakeanum* HIRATSUKA, f.<sup>1)</sup>
6. *Phragmidium Nambuianum* DIETEL
7. *Ph. arisanense* HIRATSUKA, f. et HASHIOKA
8. *Ph. Yamadanum* HIRATSUKA, f. nov. spec.
9. *Ph. alpinum* HIRATSUKA, f.
10. *Ph. Rosae-multiflorae* DIETEL

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1) The abbreviations used in this monograph are HIRATSUKA for Dr. Naoharu HIRATSUKA, the writer's father, and HIRATSUKA, f. for Naohide HIRATSUKA, the writer.

11. *Ph. mucronatum* (FR.) SCHLECHTENDAL
12. *Ph. fusiforme* SCHRÖTER
13. *Ph. montivagum* ARTHUR
14. *Ph. Rosae-rugosae* KASAI
15. *Ph. Miyabeaenum* ITO et HIRATSUKA, f.

Section *Earlea*

16. *Ph. Potentillae* (PERS.) KARSTEN
17. *Ph. brevipedicellatum* HIRATSUKA, f.
18. *Ph. papillatum* DIETEL
19. *Ph. Itoanum* HIRATSUKA, f.

Section *Phragmotelium*

20. *Ph. heterosporum* DIETEL
21. *Ph. formosanum* HIRATSUKA, f. nov. spec.
22. *Ph. Rubi-Thunbergii* KUSANO
23. *Ph. griseum* DIETEL
24. *Ph. pauciloculare* (DIET.) SYDOW
25. *Ph. Rubi-fraxinifolii* SYDOW
26. *Ph. Kamtschatkae* (ANDERS.) ARTHUR et CUMMINS

The writer wishes to express here his sincere thanks to Prof. Seiya ITO, Hokkaidô Imperial University and Dr. Gentaro YAMADA, the director of our College for their valuable suggestions. He is also under obligation to Prof. Emer. Shunsuke KUSANO of Tokyo, Prof. Kogo TOGASHI of Morioka, Mr. Torama YOSHINAGA and Mr. Yoshio HASHIOKA for their kindness in sending him many valuable specimens.

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*Phragmotelium* SYDOW in Ann. Myc. XIX, p. 167, 1921.



## Key to sections

Teleutospores germinate after a resting period. Teleutospore pedicels persistent and well developed.

Teleutospore walls verrucose with tubercles; teleutospore pedicels hygroscopic.

Sect. *Euphragmidium* ARTHUR

Teleutospore walls smooth or nearly smooth; teleutospore pedicels non-hygroscopic.

Sect. *Earlea* ARTHUR

Teleutospores germinate soon after the ripening of the spores. Teleutospore pedicels persistent, but not well developed.

Sect. *Phragmotelium* (SYDOW)

Section *Euphragmidium* ARTHUR

## Key to species

On *Rubus*.

## § Eu-form.

Teleutospore walls dark chocolate-brown to dark brown in colour.

Apical papilla of teleutospores long, up to  $21\mu$  long.

Teleutospores 4~10 septate (generally 7).

1. *Phragmidium Rubi-japonici* KASAI

Teleutospores 2~7 septate (generally 5 or 6).

2. *Phragmidium arcticum* LAGERHEIM

Apical papilla of teleutospores comparatively long, up to  $15\mu$  long.

Teleutospores 4~9 septate (generally 7).

3. *Phragmidium Rubi-Idaei* (DC.) KARSTEN

Teleutospores 2~7 septate (generally 5).

4. *Phragmidium Rubi-Oldhami* TOGASHI et MAKI

Apical papilla of teleutospores short, up to  $6\mu$  long.

Teleutospores 2~9 septate (generally 8).

5. *Phragmidium Miyakeanum* HIRATSUKA, f.

Apical papilla of teleutospores lacking.

Teleutospores 4~9 septate (generally 7),  $27\sim42\mu$  wide.

6. *Phragmidium Nambuianum* DIETEL

Teleutospores 4~8 septate (generally 6),  $24\sim39\mu$  wide.

7. *Phragmidium arisanense* HIRATSUKA, f. et HASHIOKA

Teleutospore walls light brownish yellow in colour.

Teleutospores 3~8 septate (generally 4 or 5).

8. *Phragmidium Yamadanum* HIRATSUKA, f.

## § Micro-form.

Teleutospores 3~8 septate (generally 7 or 6); apical papilla of teleutospores up to  $12\mu$  long.

9. *Phragmidium alpinum* HIRATSUKA, f.

On *Rosa*.

## § Eu-form.

Teleutospore walls dark chocolate-brown to dark brown in colour.

Teleutospore pedicels swelling broadly clavate or subglobose.

Teleutospores 5~9 septate (generally 7 or 8); apical papilla of teleutospores up to  $9\mu$  long, yellowish brown in colour.

10. *Phragmidium Rosae-multiflorae* DIETEL  
Teleutospores 3~7 septate (generally 4 or 5); apical papilla of teleutospores up to  $10\mu$  long, subhyaline.

11. *Phragmidium mucronatum* (Fr.) SCHLECHTENDAL  
Teleutospore pedicels swelling gradually to lanceolate.

Teleutospores 8~14 septate (generally 10~12); apical papilla of teleutospores up to  $12\mu$  long.

12. *Phragmidium fusiforme* SCHRÖTER  
Teleutospores 4~10 septate (generally 6~9); apical papilla of teleutospores up to  $14\mu$  long.

13. *Phragmidium montivagum* ARTHUR  
Teleutospore walls light brownish yellow in colour.

Teleutospores 5~10 septate (generally 8).

14. *Phragmidium Rosae-rugosae* KASAI

On *Sieversia*.

§ Micro-form.

Teleutospores 2~5 septate (generally 4).

15. *Phragmidium Miyabeanaum* ITO et HIRATSUKA, f.

1. *Phragmidium Rubi-japonici* KASAI in Transact. Sapporo Nat. Hist. Soc. III, p. 40, pl. I, fig. 13, 1910; HIRATSUKA, f. in Ann. Myc. XXVIII, p. 280, 1930; SACCARDO, Syll. Fung. XXIII, p. 824; SYDOW, Monogr. Ured. III, p. 148, tab. VI, fig. 63. (HIRATSUKA, f. in Transact. Sapporo Nat. Hist. Soc. IX, p. 226, 1927; SYDOW in Ann. Myc. XI, p. 109, 1913; TERUI in Transact. Sapporo Nat. Hist. Soc. XI, p. 159, 1930).

Uredosori hypophyllous, scattered or in small groups, minute, rounded or irregular in shape,  $0.1\sim0.5$  mm across, soon naked, pulvinate, finally pulverulent, orange-yellow in colour; paraphyses numerous, oblong-clavate or clavate,  $30\sim54\times10\sim15\mu$ , erect or somewhat incurved, walls smooth, colourless, thin, more or less thickened at the apex; uredospores globose, subglobose or broadly ellipsoidal,  $15\sim24\times12\sim18\mu$ ; epispore rather thin,  $0.8\sim1.5\mu$  thick, closely echinulate, nearly colourless; contents orange-yellow in colour.

Teleutosori hypophyllous, scattered or loosely grouped, minute, rounded or irregular in shape,  $0.1\sim0.6$  mm across, soon naked, pulverulent, black; teleutospores subcylindrical or clavate, 4~10 septate (generally 7),  $66\sim135\times24\sim36\mu$ , tapering or rounded at the apex, apical papilla acute, long (up to  $21\mu$ ), subhyaline, not constricted at the septa, rounded at the base, uppermost cell longer

than the rest, 3 or 4 germ pores in each cell; epispore rather thick,  $2.5 \sim 3.6 \mu$ , densely verrucose with subhyaline tubercles, dark brown to chocolate-brown in colour; pedicels persistent,  $60 \sim 144 \mu$  long,  $9 \sim 21 \mu$  at the broadest diameter, hygroscopic, nearly or quite colourless at the base and yellowish coloured at the upper part, smooth. (Pl. III, fig. 4)

**Hab.** On *Rubus pseudo-japonicus* KOIDZ. (*R. japonicus* Auct.) (*Hime-goyôichigo*).

**Hokkaidô:**—Prov. Ishikari: Jôzankei (Oct. 12, 1902, G. YAMADA, *type!*; Oct. 17, 1930, Y. IMAI); Sôunkei (Aug. 17, 1925, HIRATSUKA, f.). Prov. Kitami: Mt. Rishiri (July 15, 1930, M. TERUI). Prov. Tokachi: Kuttari (July 7, 1926, HIRATSUKA, f.). Prov. Kushiro: Mt. Meakan (Aug. 19, 1931, Y. TOKUNAGA; Sept. 14, 1925, HIRATSUKA, f.); Mt. Oakan (Sept. 10, 1925, HIRATSUKA, f.); Shirikoma-betsu (Akan) (Sept. 11, 1925, HIRATSUKA, f.).

**Honshû:**—Prov. Rikuchû: Mt. Iwate (Oct. 3, 1903, G. YAMADA).

**Distribution.** Japan (*Hokkaidô* and *Honshû*).

This species was first described by KASAI (42) in 1910 based upon three specimens of the teleutostage on *Rubus pseudo-japonicus* KOIDZ.<sup>1)</sup> which were collected at Jôzankei, Ishikari Province (*Hokkaidô*). But, the uredostage of this fungus has remained undescribed until 1930, when the writer (29) recorded it on the same host plant.

The present species is closely related to *Phragmidium Rubi-Idaei* (DC.) KARST. and *Ph. arcticum* LAGERH. From *Phragmidium Rubi-Idaei*, this species is easily distinguished by the long and acute apical papilla of its teleutospores and also by the shorter teleutospore pedicels. From *Phragmidium arcticum*, it distinctly differs in the larger number of teleutospore-septa as well as in somewhat shorter teleutospore pedicels.

So far as our present knowledge is concerned, this species is found only in the northern Honshû and Hokkaidô.

2. *Phragmidium arcticum* LAGERHEIM in VESTERGREN, *Micromycetes rariores selecti*, no. 856, 1904; LIRO, *Ured. Fenn.* p. 419;

1) In the original description of this species, KASAI gives its host as *Rubus japonicus* MAXIM., but that must be an error for *Rubus pseudo-japonicus* KOIDZ.

SACCARDO, Syll. Fung. XXI, p. 729; SYDOW, Monogr. Ured. III, p. 145; VLEUGEL in Svensk Bot. Tidskr. II, p. 137, 1908. (HIRATSUKA, f. in Mem. Tottori Agric. Coll. I, p. 76, 1930; KAWAI & OTANI in Transact. Sapporo Nat. Hist. Soc. XI, p. 231, 1931).

**Syn.** *Phragmidium Rubi* (not WINTER) (KASAI in Transact. Sapporo Nat. Hist. Soc. III, p. 39, pl. I, fig. 11, 1910).

Spermogonia not seen.

Aecidia hypophyllous, scattered or loosely grouped, minute, rounded, 0.5~0.75 mm across, elongated on the nerves, up to 5 mm long, orange in colour; paraphyses numerous, cylindrical-clavate, up to 55  $\mu$  long, 10~14  $\mu$  wide, incurved, walls smooth, hyaline; aecidiospores globose, subglobose, ellipsoidal or ovate, 17~25  $\times$  14~20  $\mu$ ; epispore verrucose, about 2.5  $\mu$  thick. (After SYDOW)

Uredosori hypophyllous, scattered or gregarious, often thickly scattered over the whole surface, minute, round, 0.2~0.8 mm across, early naked, pulverulent, yellow in colour; paraphyses numerous, cylindrical or clavate, 30~55  $\times$  8~15  $\mu$ , strongly incurved, walls smooth, colourless, thin, more or less thicker at the apex; uredospores globose, subglobose, ovate or broadly ellipsoidal, 20~28  $\times$  15~22  $\mu$ ; epispore minutely echinulate, rather thin, 1~1.5  $\mu$  thick; contents orange-yellow in colour.

Teleutosori hypophyllous, scattered or gregarious, minute, rounded or irregular in shape, 0.2~0.6 mm across, early naked, pulvinate, finally pulverulent, black; teleutospores cylindrical, 2~8 septate (generally 5 or 6), 45~102  $\times$  24~36  $\mu$ ; not constricted at the septa, rounded at the base, slightly attenuate at the apex, apical papilla acute, 3~18  $\mu$  long, nearly or quite colourless, 2 or 3 germ pores in each cell; epispore minutely verrucose with hyaline or subhyaline tubercles, rather thick (3~4  $\mu$ ), olive-brown to dark brown in colour; pedicels persistent, 39~147  $\mu$  long, 8~18  $\mu$  at the broadest diameter, colourless, smooth, hygroscopic.

**Hab.** On *Rubus arcticus* L. (*Chishima-ichigo*).

*S. Saghalien*:—Shisuka (Aug. 21, 1906, T. MIYAKE; Aug. 13, 1928, HIRATSUKA, f.); Kushunnai (Sept. 8, 1907, T. MIYAKE).

**Distribution.** Northern Europe, Ural, Kamtchatka and Japan (*S. Saghalien*).

The writer has been enabled to examine through the courtesy of Dr. KUSANO, a part of the original specimen of this species which

was issued in "VESTERGREN, Micromycetes rariores selecti, no. 856". This collection was made by J. VLEUGEL on the Island of Granö near Umea in Sweden, in August 1904.

The first announcement of this fungus from Japan was made by KASAI (42) in 1910. He identified this fungus on *Rubus arcticus* L. which was collected by T. MIYAKE in South Saghalien with *Phragmidium Rubi* (PERS.) WINT. Recently, the writer (30) and KAWAI & OTANI (44) also reported it from South Saghalien.

This species closely resembles *Phragmidium Rubi* (PERS.) WINT., from which it can be distinguished by the larger number of teleutospore-septa, long apical papilla of the teleutospores and others. This fungus is also related to *Phragmidium Rubi-japonici* KASAI, but distinction between them is noticeable as the writer has already pointed out under the latter species.

As far as the writer knows, the present species is known only from South Saghalien in our country. The writer has not seen the aecidial stage of this fungus and can only quote the description given by the SYDOWS (56).

3. *Phragmidium Rubi-Idaei* (DC.) KARSTEN, Myc. Fenn. IV, p. 52, 1878; GROVE, Brit. Rust Fungi, p. 298, fig. 226; JØRSTAD in Skrift. utgitt av Det Norske Videnskaps-Akad. Oslo, I. Matem.-Natur. Kl. (1933), no. 9, p. 67, 1934; KLEBAHN in Kryptogamenfl. Mark Brandenbr. Va, p. 670, p. 666, fig. El; SACCARDO, Syll. Fung. VII, p. 748; SYDOW, Monogr. Ured. III, p. 146. (HIRATSUKA, f. in Transact. Sapporo Nat. Hist. Soc. IX, p. 226, 1927, p.p.; Mem. Tottori Agric. Coll. I, p. 76, 1930; KAWAI & OTANI in Transact. Sapporo Nat. Hist. Soc. XI, p. 231, 1931; SYDOW in Ann. Myc. XI, p. 109, 1913; TOGASHI in Jap. Jour. Bot. II, p. 84, 1924).

Syn. *Uredo Rubi-Idaei* PERS., Observ. Myc. II, p. 24, 1799.

*Puccinia Rubi-Idaei* DC. in Fl. franç. VI, p. 54, 1815.

*Phragmidium incrassatum* LINK var. *gracile* FARL. in ELLIS, N. Amer. Fung. no. 282, 1879.

*Phragmidium Rubi-Idaei* WINT. in Pilze Deutschl. I, p. 231, 1881; FISCHER, Ured. Schw. p. 420, fig. 291; PLOWRIGHT, Monogr. Brit. Ured. & Ustil. p. 226. (KASAI in Transact. Sapporo Nat. Hist. Soc. III, p. 39, pl. I, fig. 12, 1910).

*Phragmidium gracile* ARTH. in Bull. Iowa Agric. Coll. (1884), p. 161, 1884; SACCARDO, Syll. Fung. VII, p. 749; SYDOW, Monogr. Ured. III, p. 154, pl. VI, fig. 66.



*Phragmidium imitans* ARTH. in N. Amer. Fl. VII, p. 165, 1912.

Spermogonia epiphyllous, in small groups, yellow,  $45\sim60\mu$  across. (After SYDOW).

Aecidia epiphyllous, scattered or irregularly grouped, minute, round,  $0.28\sim1$  mm across, early naked, pulvinate, orange-yellow in colour, ruptured epidermis conspicuous; paraphyses numerous, clavate,  $40\sim78\mu$  long,  $12\sim18\mu$  wide, somewhat incurved, walls colourless, thin, slightly thickened at the apex, smooth; aecidiospores subglobose, obovate or broadly ellipsoidal,  $17\sim25\times14\sim18\mu$ ; epispore nearly colourless, about  $2\mu$  thick, strongly echinulate; contents orange-yellow in colour.

Uredosori hypophyllous, scattered or gregarious, often thickly scattered over the whole surface, pulverulent, orange-yellow in colour; paraphyses numerous, cylindrical or clavate,  $40\sim80\mu$  long,  $12\sim24\mu$  wide, suberect or incurved, walls uniformly thin, colourless, smooth; uredospores subglobose, broadly ellipsoidal or obovate,  $18\sim27\times14\sim20\mu$ ; epispore aculeate or aculeate-verrucose, nearly colourless,  $1.8\sim2.5\mu$  thick; contents orange-yellow in colour.

Teleutosori hypophyllous, scattered or gregarious, often thickly scattered over the whole surface of leaves, minute, early naked, pulverulent, black; teleutospores cylindrical,  $4\sim10$  septate (generally 7),  $80\sim144\times27\sim39\mu$ ; not constricted at the septa, rounded at the base, rounded or somewhat attenuate at the apex, apical papilla up to  $15\mu$  long, subhyaline, 3 germ pores in each cell; epispore chestnut-brown to olive-brown in colour, rather thick,  $3\sim4.5\mu$  thick, densely verrucose with colourless or subhyaline tubercles; pedicels persistent, up to  $165\mu$  long,  $12\sim16\mu$  wide at the upper part, wider at the base (up to  $21\mu$ ), nearly or quite colourless and pale yellowish coloured near the spore, hygroscopic at the lower part. (Pl. III, fig. 5)

**Hab.** On *Rubus Idaeus* L. var. *aculeatissimus* RGL. et TIL. (*R. Idaeus* L. var. *strigosa* MAXIM.) (*Yezo-ichigo*).

*S. Saghalien*:—Takinosawa (Motodomari) (July 28, 1928, HIRATSUKA, f.); Higashishiraura (July 8, 1927, HIRATSUKA, f.); Kita-Nayoshi (Aug. 27, 1929, Y. TOKUNAGA & K. KAWAI).

*Hokkaidô*:—Prov. Ishikari: Jôzankei (Oct. 12, 1902, G. YAMADA; Oct. 17, 1930, Y. IMAI; Sept. 25, 1927, HIRATSUKA, f.); Takikawa (July, 1895, K. SENGOKU); Mt. Kuro-dake (Aug. 16, 1925 & Sept. 12, 1926, HIRATSUKA, f.); Mt. Soranuma (Sept. 18, 1930, Y. IMAI); Mt.

Teine (Sept. 27, 1925, HIRATSUKA, f.). Prov. Kushiro: Nanamagari (Akan) (Aug. 6, 1923, HIRATSUKA, f.); Bokke (Akan) (Sept. 13, 1925, HIRATSUKA, f.); Mt. Oakan (Sept. 10, 1925, HIRATSUKA, f.); Shitakara (Sept. 13, 1925, HIRATSUKA, f.); Nipushi (Lake-side of Kutcharo-ko) (Aug. 22, 1929, HIRATSUKA). Prov. Kitami: Oshidomari (Rishiri) (Oct. 10, 1923, K. TOGASHI); Momoiwa (Rebun) (Aug. 9, 1922, K. TOGASHI).

*Kuriles*:—Kunashiri: Furukamappu (Aug. 11, 1929, M. NAGAI & M. SHIMAMURA); Zenbekotan (Tomari-mura) (H. TANAKA). Etorofu: Shana (Aug., 1924, A. ABE); Shibetoro (July 21, 1906, K. MIURA).

On *Rubus Idaeus* L. var. *concolor* NAKAI (*Chôsen-kiichigo*).

*Hokkaidô*:—Prov. Ishikari: Mt. Teine (Sept. 29, 1925, HIRATSUKA, f.); Mt. Sapporo (Sept. 5, 1921, K. TOGASHI); Jôzankei (Sept. 25, 1927, HIRATSUKA, f.).

**Distribution.** Europe, North America, Caucasus, W. Turkestan, Siberia, Kamtchatka, North Saghalien and Japan (*S. Saghalien, Hokkaidô and the Kuriles*).

In 1910, this species was first recorded by KASAI (42) from our country, and after his record, it was also reported by the SYDOWS (57), TOGASHI (62), KAWAI & OTANI (44) and the writer (27, 30).

This fungus is rather common in northern Japan, especially in South Saghalien, Hokkaidô and the Kuriles, and it is also widely distributed in temperate regions of the Northern Hemisphere.

4. *Phragmidium Rubi-Oldhami* TOGASHI et MAKI in HIRATSUKA, f. in Transact. Sapporo Nat. Hist. Soc. XIII, p. 138, 1934.

Uredosori hypophyllous, scattered or gregarious, round, small, 0.1~0.4 mm across, early naked, somewhat pulverulent, yellow in colour; paraphyses numerous, cylindrical or clavate, 35~70 × 10~18  $\mu$ , incurved, walls thin, 1  $\mu$  or less, occasionally slightly thickened at the apex, smooth; uredospores globose, subglobose, broadly ellipsoidal or obovate, 14~25 × 12~20  $\mu$ ; epispore rather thin, 1.5~2  $\mu$  thick, densely and strongly echinulate, colourless; contents yellow in colour.

Teleutosori hypophyllous, scattered or grouped, rounded or irregular in shape, 0.2~1.5 mm across, sometimes confluent, early naked, pulverulent, black; teleutospores mostly cylindrical or fusoid-cylindrical, 2~7 septate (generally 5), 32~108 × 24~32  $\mu$ ; not

constricted at the septa, rounded at both ends, apical papilla  $1 \sim 12.5 \mu$  long, colourless or subhyaline, 3 germ pores in each cell; epispore chestnut-brown to dark brown in colour, densely verrucose with colourless or subhyaline tubercles, moderately thick ( $2 \sim 4 \mu$ ); pedicels persistent,  $42 \sim 144 \mu$  long,  $6 \sim 12 \mu$  wide at the upper part, wider at the base ( $10 \sim 20 \mu$ ), nearly or quite colourless, somewhat rugose at the lower part, hygroscopic.

**Hab.** On *Rubus Oldhami* MIQ. (*R. pungens* CAMB. var. *Oldhami* MAXIM.) (*Sanagi-ichigo*).

*Honshû*:—Prov. Rikuchû: Morioka (Nov. 7 & 14, 1931, Y. MAKI, type!).

**Distribution.** Japan (*Honshû*).

The present fungus seems to be closely related to the European species, *Phragmidium Rubi-saxatilis* LIRO. But, it is distinctly distinguishable from the latter species by the smaller number of septa, shorter apical papilla and longer pedicels of the teleutospores.

Hitherto it has been collected only in the province of Rikuchû.

5. *Phragmidium Miyakeanum* HIRATSUKA, f. in Transact. Tottori Soc. Agric. Sci. II, p. 242, 1931.

**Syn.** *Phragmidium Rubi-Idaei* (not KARSTEN) (HIRATSUKA, f. in Transact. Sapporo Nat. Hist. Soc. IX, p. 226, 1927, p.p.).

Soris uredosporiferis hypophyllis, sparsis vel laxe aggregatis, minutis, mox nudis, pulverulentis, flavidis; paraphysibus numerosis, clavatis,  $42 \sim 80 \times 10 \sim 22 \mu$ ; uredosporis globosis, subglobosis, obovatis vel ellipsoideis, echinulatis,  $17.5 \sim 24 \times 15 \sim 18 \mu$ ; episporio  $1 \sim 1.5 \mu$  crasso.

**Hab.** in foliis *Rubi Kinashii* in Hokkaidô, Japonia.

Uredosori hypophyllous, scattered or grouped, minute, early naked, pulverulent, yellow in colour; paraphyses numerous, clavate,  $42 \sim 80 \times 10 \sim 22 \mu$ , erect or somewhat incurved, walls uniformly thin,  $1 \mu$  or less, smooth, nearly colourless; uredospores globose, subglobose, obovate or broadly ellipsoidal,  $17.5 \sim 24 \times 15 \sim 18 \mu$ ; epispore densely and strongly echinulate, thin,  $1 \sim 1.5 \mu$  thick.

Teleutosori hypophyllous, scattered or loosely grouped, very minute, early naked, pulverulent, black; teleutospores cylindrical,  $5 \sim 9$  septate (generally 7 or 8),  $75 \sim 147 \times 24 \sim 42 \mu$ , not constricted at the septa, rounded at both ends, apical papilla very short,  $0.5 \sim 6 \mu$  long, subhyaline, 3 germ pores in each cell; epispore densely verrucu-

lose with hyaline or subhyaline warts, dark brown to dark chocolate-brown in colour, rather thick,  $3\sim5\mu$ ; pedicels persistent,  $54\sim150\mu$  long, colourless or pale yellowish coloured near the spore, swelling in water to oblongate or narrowly ellipsoidal, up to  $25\mu$  at the broadest diameter.

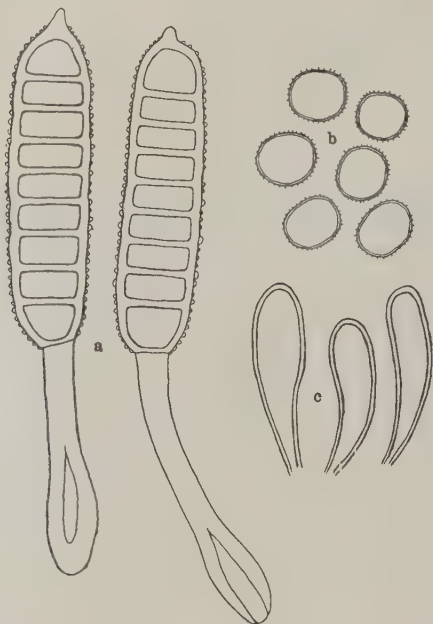


Fig. 1. *Phragmidium Miyakeanum* HIRATS. f. on *Rubus Kinashii* LÉV. et VNT. (Mt. Oakan, prov. Kushiro, Sept. 10, 1925, leg. HIRATSUKA, f.). a. Teleutospores. b. Uredospores. c. Paraphyses in uredosori.<sup>(1)</sup>

**Hab.** On *Rubus Kinashii* LÉV. et VNT. (*Kuro-ichigo*).

*S. Saghalien*:—Kashipo (Aug. 23, 1928, HIRATSUKA, f., *type*!).

*Hokkaidô*:—Prov. Kushiro: Mt. Oakan (Sept. 10, 1925, HIRATSUKA, f., *type of the uredostage*!).

(1) In this and following text-figures, the drawings were outlined with the aid of a camera lucida at a uniform scale and were reduced equally in reduction, representing approximately a magnification of 400 diameters.

**Distribution.** Japan (*S. Saghalien* and *Hokkaidô*).

This species closely resembles *Phragmidium Nambuanum* DIET. on the same host in the essential characters of uredo- and teleuto-stages except for the absence of apical papilla of the teleutospores. This fungus is also related to *Phragmidium Rubi-Idaei* (DC.) KARST. from which it may be distinguished by its shorter apical papilla of the teleutospores as well as by its broader teleutospores. The writer, therefore, considers that this fungus serves as a connecting link between *Phragmidium Rubi-Idaei* (DC.) KARST. and *Ph. Nambuanum* DIET.

The present species was created by the writer (32) based upon a specimen which was collected by him at Kashipo, South Saghalien. He found recently that a fungus on the same host which was collected by him in Mt. Oakan, Hokkaidô and was already reported by him as *Phragmidium Rubi-Idaei* (PERS.) KARST. in 1927, is really identical with this species. Moreover, a number of the uredosori which have never been described, was found on the same collection.

The specific name of the present species was given in honor of Dr. Tsutome MIYAKE who had studied the rust-flora of South Saghalien.

6. *Phragmidium Nambuanum* DIETEL in Ann. Myc. VI, p. 227, 1908; KASAI in Transact. Sapporo Nat. Hist. Soc. III, p. 38, pl. I, fig. 10, 1910; SACCARDO, Syll. Fung. XXI, p. 730; SYDOW, Monogr. Ured. III, p. 148, tab. VI, fig. 62. (HIRATSUKA, f. in Transact. Sapporo Nat. Hist. Soc. IX, p. 226, 1927; NAMBU in Bot. Mag. Tokyo, XXIII, p. (310), fig. 8, p. (311), 1909; SYDOW in Ann. Myc. XI, p. 109, 1913).

Soris uredosporiferis hypophyllis, sparsis vel aggregatis, minutis, rotundatis, 0.12~0.6 mm diam., pulverulentis, aurantiacis; paraphysibus numerosis,  $48\sim60\times10\sim20\mu$ ; uredosporis globosis, subglobosis, ellipsoideis vel obovatis, minutissime echinulatis,  $20\sim26.5\times18\sim23\mu$ ; episporio  $0.8\sim1.2\mu$  crasso, hyalino.

**Hab.** in foliis *Rubi Kinashii* in Hokkaidô, Japonia.

Uredosori hypophyllous, scattered or in small groups, minute, rounded or irregular in shape, 0.12~0.6 mm across, early naked, finally pulverulent, orange-yellow in colour; paraphyses numerous, clavate,  $48\sim60\times10\sim20\mu$ , suberect or incurved, walls uniformly thin,  $1\mu$  or less, colourless, smooth; uredospores globose, subglobose,



broadly ellipsoidal or obovate,  $20 \sim 26.5 \times 18 \sim 23 \mu$ ; epispore minutely echinulate, thin,  $0.8 \sim 1.5 \mu$  thick, colourless; contents orange-yellow in colour.

Teleutospores hypophyllous, scattered or loosely aggregate, minute, rounded or irregular in shape, soon naked, pulverulent, black; teleutospores cylindrical or cylindrical-oblong,  $4 \sim 9$  septate (generally 7 or 8),  $72 \sim 147 \times 24 \sim 42 \mu$ , rounded at both ends, not constricted at the septa, 3 or 4 germ pores in each cell, apical papilla wanting; epispore verruculose with colourless or subhyaline tubercles, rather thick ( $4 \sim 6 \mu$ ), dark brown to dark chocolate-brown in colour; pedicels persistent,  $54 \sim 150 \mu$  long,  $10 \sim 24 \mu$  at the broadest diameter, nearly or quite colourless, smooth, hygroscopic. (Pl. III, fig. 3)

**Hab.** On *Rubus Kinashii* LÉV. et VNT. (*R. occidentale* var. *japonicus* MIYABE) (*Kuro-ichigo*).

**Hokkaidô:**—Prov. Ishikari: Mt. Moiwa (Oct. 11, 1901, K. MIYABE; Oct. 17, 1897, G. YAMADA); Jōzankei (M. MIURA); Mt. Teine (Sept. 9, 1921, H. TAKASUGI; Oct. 5, 1923, HIRATSUKA, f.); Sōunkei (Aug. 16, 1925, HIRATSUKA, f.). Prov. Iburi: Mt. Eniwa (Aug. 6, 1902, K. MIYABE & S. ARIMOTO). Prov. Kushiro: Mt. Oakan (Aug. 10, 1923, HIRATSUKA, f.).

**Distribution.** Japan (*Hokkaidô* and *Honshū*).

In 1908, DIETEL (16) created the present species based upon a collection made by N. NAMBU at Nikkō, Shimotsuke Province in October 1907. Since then, KASAI (42), the SYDOWS (57), NAMBU (51) and the writer (27) reported also the occurrence of this fungus in Hokkaidô and Honshū, Japan. But, the uredostage of this fungus has never been described. The writer was able, however, to observe that stage on specimens collected by himself in Hokkaidô.

The present fungus resembles *Phragmidium arisanense* HIRATS. f. et HASHIOKA from which it differs, however, in the number of teleutospore-septa, in the width of the teleutospores as well as in the length of the teleutospore pedicels. The number of the teleutospore-septa of this species is 4 to 9 (generally 7 or 8), while in the case of *Phragmidium arisanense* it is 4 to 7 (generally 5 or 4). The length of the pedicels of the present fungus is also always longer than that of the latter species. Moreover, the teleutospores of the former species are broader in width than those of the latter.

7. *Phragmidium arisanense* HIRATSUKA, f. et HASHIOKA in HIRATSUKA, f. in Transact. Sapporo Nat. Hist. Soc. XIII, p. 137, 1934.

Uredosori hypophyllous, scattered or in small groups, round, minute, 0.2~0.8 mm across, early naked, somewhat pulverulent, orange-yellow in colour; paraphyses numerous, cylindrical or clavate, 50~80  $\mu$  long, 12~20  $\mu$  wide, somewhat incurved, walls smooth, thin, colourless; uredospores globose, subglobose, obovate or broadly ellipsoidal, 17~25  $\times$  15~22  $\mu$ ; epispore coarsely echinulate, colourless, 1.2~2  $\mu$  thick; contents orange-yellow in colour.

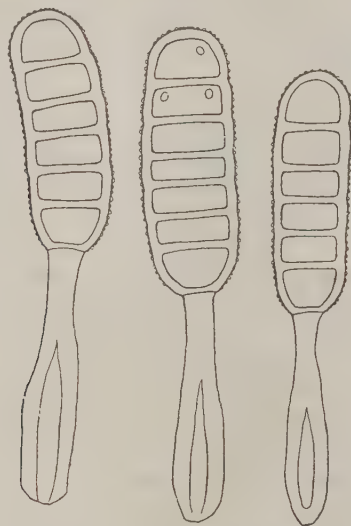


Fig. 2. Teleutospores of *Phragmidium arisanense* HIRATS. f. et HASHIOKA on *Rubus rarissimus* HAYATA. (Mt. Arisan, prov. Tainan, Nov. 6, 1932, leg. Y. HASHIOKA, type!).

Teleutosori hypophyllous, scattered or gregarious, minute, rounded or irregular in shape, 0.2~0.4 mm across, early naked, pulverulent, black; teleutospores cylindrical, 4~7 septate (generally 5 or 4), 60~114  $\times$  25~39  $\mu$ , apical papilla wanting, rounded at both ends, not constricted at the septa, 3 germ pores in each cell; epispore verrucose with colourless or subhyaline warts, 2.5~4  $\mu$  thick, chestnut-brown to dark brown in colour; pedicels persistent, 33~102  $\mu$

long, up to  $20\ \mu$  at the broadest diameter, hygroscopic, colourless, smooth.

**Hab.** On *Rubus rarissimus* HAYATA (*Arisan-miyama-urajiro-ichigo*).

*Formosa*:—Prov. Tainan: Mt. Arisan (July 12, 1933 & Nov. 6, 1932, Y. HASHIOKA, *type!*).

**Distribution.** Japan (*Formosa*).

The present species is closely related to *Phragmidium Nambu-anum* DIET. But distinction between them is noticeable, as the writer has already described under the latter species.

This species seems to have a narrow range of distribution. The writer has only the above two collections made by Mr. HASHIOKA in Mt. Arisan, Formosa.

8. *Phragmidium Yamadanum* HIRATSUKA, f. nov. spec.

Soris uredosporiferis hypophyllis, sparsis, minutis, rotundatis,  $0.1\sim 0.3$  mm diam., mox nudis; paraphysibus numerosis, clavatis,  $45\sim 64\times 12\sim 20\ \mu$ ; uredosporis ellipsoideis, obovatis vel oblongis, echinulatis,  $20\sim 27\times 13.5\sim 18\ \mu$ ; episporio  $1.2\sim 1.8\ \mu$  crasso.

Soris teleutosporiferis hypophyllis, sparsis vel aggregatis, minutis, pulverulentis, atro-brunneis; teleutosporis cylindraceis,  $4\sim 7$ -septatis (raro tandem 3- vel 8-septatis), ad septa non constrictis, apice papilla hyalina vel subhyalina, brevi, usque  $5\ \mu$  longa auctis, basi rotundatis, verrucis minutis sparsis obsitis, flavo-brunneis,  $60\sim 135\times 21\sim 30\ \mu$ , quaque cellula poris germinationis 3 instructa; pedicello hyalino vel subhyalino, superne leniter flavidulo,  $42\sim 78\ \mu$  longo, deorsum incrassato ( $15\sim 24\ \mu$ ).

**Hab.** in foliis *Rubi japonici* in Honshû, Japonia.

Uredosori hypophyllous, scattered, minute, round,  $0.1\sim 0.3$  mm across, early naked; paraphyses numerous, clavate or broadly clavate,  $45\sim 65\times 12\sim 20\ \mu$ , erect or somewhat incurved, walls smooth, colourless, more or less thickened above ( $3\sim 4\ \mu$ ); uredospores ellipsoidal, obovate or oblong,  $20\sim 27\times 13.5\sim 18\ \mu$ ; epispore minutely echinulate,  $1.2\sim 1.8\ \mu$  thick.

Teleutosori hypophyllous, scattered or gregarious, minute, naked, pulverulent, blackish brown in colour; teleutospores cylindrical,  $4\sim 7$  septate (rarely 3 or 8),  $60\sim 135\times 21\sim 30\ \mu$ , rounded at both ends or often somewhat attenuate at the apex, not constricted at the septa, apical papilla very short (up to  $5\ \mu$  long), colourless to subhyaline,

smooth, 3 germ pores (rarely 4) in each cell; epispore rather thick ( $2.5 \sim 3.5 \mu$ ), sparsely covered with a few coarse subhyaline tubercles, light brownish yellow in colour; pedicels persistent,  $42 \sim 78 \mu$  long, smooth, swelling abruptly to broadly clavate,  $15 \sim 24 \mu$  at the broadest diameter, colourless to subhyaline or pale yellowish coloured near the spore.

**Hab.** On *Rubus japonicus* MAXIM. (*Goyô-ichigo*).

**Honshû:**—Prov. Rikuchû: Kunimi-tôge (Aug. 11, 1904, G. YAMADA, type!).

**Distribution.** Japan (*Honshû*).

Material of this fungus is very scanty, as the writer has found only few sori. Therefore, the above description may be incomplete. But, the present fungus is distinctly distinguishable from the other species of the section *Euphragmidium* on *Rubus* by the colour and tuberculation of the walls of teleutospores and shorter pedicels of the spores.

The writer has named this species after the family name of Dr. Gentaro YAMADA, the director of our College, who collected this interesting fungus.

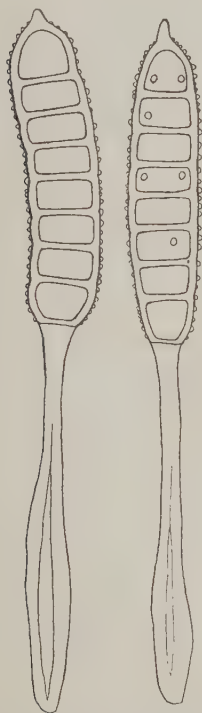


Fig. 3. Teleutospores of *Phragmidium alpinum* HIRATS. f. on *Rubus pedatus* SM. (Mt. Kuro-dake, prov. Ishikari, Sept. 11, 1926, leg. HIRATSUKA, f., type!)

9. *Phragmidium alpinum* HIRATSUKA, f. in Ann. Myc. XXVIII, p. 280, 1930. (HIRATSUKA, f. in Transact. Tottori Soc. Agric. Sci. II, p. 215, 1931; III, p. 215, 217, 219, 243, 1931; Bot. & Zool. II, p. 544, 545; p. 543, fig. 5, 1934).

Teleutosori hypophyllous, scattered or solitary, medium-size, round or ellipsoidal,  $1 \sim 4 \text{ mm}$  across, at first covered by the epidermis, then naked, pulvinate, finally pulverulent, ruptured epidermis conspicuous, black; teleutospores cylindrical,  $3 \sim 8$  septate (generally 6 or 7),  $66 \sim 144 \times 21 \sim 36 \mu$ , not constricted at the septa, rounded at

both ends, apical papilla acute,  $3\sim 12\mu$  long; epispore densely verruculose with hyaline or subhyaline tubercles, clove brown to blackish brown in colour, moderately thick ( $3\sim 5\mu$ ), 3 germ pores in each cell; pedicels persistent,  $90\sim 168\mu$  long, up to  $18\mu$  at the broadest diameter, smooth, nearly or quite colourless and pale yellowish coloured near the spore, hygroscopic. (Pl. III, fig. 2)

**Hab.** On *Rubus pedatus* SM. (*Kogane-ichigo*).

*S. Saghalien*:—Mt. Tosso (July 30, 1928, HIRATSUKA, f.)

*Hokkaidô*:—Prov. Ishikari: Mt. Kuro-dake (Aug. 19, 1925; Sept. 11, 1926, HIRATSUKA, f., *type!*; Aug. 12, 1927, S. ITO, HIRATSUKA, f. & S. IWADARE); Mt. Nisekaushipe (Aug. 28, 1929, M. OKAMOTO). Prov. Iburi: Tomamu (Aug. 9, 1926, M. OKAMOTO).

*Honshû*:—Prov. Shinano: Mt. Yatsugatake (Aug. 9, 1926, G. YAMADA; July 21, 1930, HIRATSUKA, f.); Mt. Tsubakura (July 29 & Aug. 2, 1930, HIRATSUKA, f.); Mt. Komagatake (Kiso) (Aug. 10 & 11, 1931; Aug. 23 & 24, 1932, HIRATSUKA, f.).

**Distribution.** Japan (*S. Saghalien*, *Hokkaidô* and *Honshû*).

This species belongs to a *Micro-Phragmidium*, and it is one of the alpine species. As far as the writer knows, this fungus is found only in the alpine regions of northern Japan.

10. *Phragmidium Rosae-multiflorae* DIETEL in Hedwigia XLIV, p. 132, pl. IV, fig. 8, 1905; KASAI in Transact. Sapporo Nat. Hist. Soc. III, p. 32, pl. I, fig. 5, 1910; SACCARDO, Syll. Fung. XXI, p. 727; SYDOW, Monogr. Ured. III, p. 123, tab. V, fig. 53; TAI in Nanking Jour. II, p. 176, fig. 16, 1932. (DIETEL in Ann. Myc. VIII, p. 310, 1910; FUJIKURO in Transact. Formosa. Nat. Hist. Soc. no. 19, p. (8), 1914; HIRATSUKA, f. in Transact. Tottori Soc. Agric. Sci. IV, p. 38, 1932; SAWADA in Dept. Agric. Govern. Res. Inst. Formosa, Rept. no. 35, p. 36, 1928; SYDOW in Ann. Myc. XI, p. 109, 1913; TOGASHI & ONUMA in Bull. Imp. Coll. Agric. & Forestr. Morioka, XVIII, p. 19, 1934; TOKUBUCHI in MIYABE-Festschrift, p. (308), 1911; YOSHINAGA, & HIRATSUKA, f. in Bot. Mag. Tokyo, XLIV, p. 649, 1930).

**Syn.** *Phragmidium subcorticium* (not SCHRÖTER nor WINTER) (DIETEL in ENGL. Bot. Jahrb. XXVIII, p. 285, 1900; NAMBU in Bot. Mag. Tokyo, XXIII, p. (309), p. (310), fig. 1, 1909, p.p.; YOSHINAGA in Bot. Mag. Tokyo, XVI, p. (3), 1902; YOSHINO in Bot. Mag. Tokyo, XIX, p. (96), 1905).

**Exsiccati:** SYDOW, Fung. exot. exs. no. 478.



Spermogonia not seen.

Aecidia hypophyllous or petiolicolous, occasionally on fruits or young shoots, generally elongated on nerves of the leaves, petioles and shoots, up to 2 cm long, pulvinate, finally somewhat pulverulent, ruptured epidermis conspicuous, orange-yellow in colour; paraphyses none; aecidiospores globose, subglobose or ellipsoidal,  $20 \sim 30 \times 15 \sim 22 \mu$ ; epispore verrucose,  $1.8 \sim 2.8 \mu$  thick, nearly colourless; contents orange-yellow in colour.

Uredosori hypophyllous, scattered or loosely grouped, minute, rounded or irregular in shape,  $0.2 \sim 0.6$  mm across, early naked, somewhat pulverulent, orange-yellow in colour; paraphyses numerous, cylindrical, clavate or broadly clavate,  $35 \sim 60 \times 12 \sim 18 \mu$ , suberect or incurved, around the sorus, walls smooth, thin,  $1 \sim 2.5 \mu$  thick, colourless; uredospores globose, subglobose, broadly ellipsoidal or obovate,  $18 \sim 25 \times 15 \sim 21 \mu$ ; epispore rather thick,  $2 \sim 3 \mu$ , minutely verruculose, colourless; contents orange-yellow in colour.

Teleutosori hypophyllous, scattered or grouped, often thickly scattered over the whole surface, minute, rounded or irregular in shape,  $0.2 \sim 0.4$  mm across, early naked, pulverulent, black; teleutospores cylindrical,  $4 \sim 9$  septate (generally 7 or 8),  $69 \sim 117 \times 20 \sim 30 \mu$ ; rounded at both ends, often somewhat attenuate at the apex, not constricted at the septa, apical papilla conical, up to  $10 \mu$  long, yellowish brown in colour, smooth, 3 germ pores in each cell; epispore rather thick,  $2.4 \sim 3.5 \mu$ , densely and minutely verruculose with colourless or subhyaline tubercles, olive brown to dark brown in colour; pedicels persistent,  $60 \sim 129 \mu$  long, swelling broadly clavate or subglobose at the lower half, up to  $30 \mu$  at the broadest diameter, brownish yellow at the upper half, nearly or quite colourless at the lower half.

**Hab.** On *Rosa polyantha* SIEB. et ZUCC. var. *genuina* NAKAI (*R. multiflora* THUNB.) (*No-ibara*).

**Hokkaidô:**—Prov. Oshima: Hakodate (July 10, 1890, K. MIYABE); Mt. Komagatake (July 4, 1920, K. TOGASHI; Sept. 28, 1924, HIRATSUKA, f.); Nakayama-tôge (Oct. 27, 1922, HIRATSUKA, f.). Prov. Ishikari: Hirakishi-mura (Aug. 8, 1894, HIRATSUKA); Sapporo (June 28, 1891, E. TOKUBUCHI; June 24 & Nov. 1, 1908, M. KASAI; July 19, 1896; Sept. 8, 1894, HIRATSUKA; June 15, 1920, K. TOGASHI; Oct. 22, 1921, HIRATSUKA, f.); Mt. Moiwa (June 11, July 3 & Sept. 14, 1924, HIRATSUKA, f.).

*Honshû*:—Prov. Mutsu: Goshogawara (Oct., 1904, T. KASHI-WAI); Shimidzu-mura near Hirosaki (Sept. 25, 1926, S. ITO & HIRATSUKA, f.). Prov. Ugo: Ueda-machi (Aug. 25, 1928, F. ONUMA). Prov. Rikuchû: Morioka (July, 1916, Nov., 1911 & July 5, 1903, G. YAMADA; June 15, 1927, K. TOGASHI); Fukuoka (Oct. 13, 1910, G. YAMADA); Iioka (July 9, 1905, G. YAMADA); Dake (Aug. 21, 1909, G. YAMADA); Takizawa (May 26, 1907, G. YAMADA & K. SAWADA; June 2, 1906, K. SAWADA); Nanshōzan (Sept. 30, 1906, K. SAWADA); Asakishi (Oct. 21, 1906, G. YAMADA); Mt. Himekami (June 5, 1927, K. CHIBA); Kuzumaki (July 6, 1907, M. MIURA); Kuji (July 20, 1932, K. TOGASHI); Matsukusa (June 16, 1931, K. TOGASHI); Mt. Iwate (June 27, 1908, G. YAMADA); Mt. Hayachine (Aug. 21, 1909, G. YAMADA; July 26 & 27, 1928, K. TOGASHI; Sept. 16, 1928, F. ONUMA; July 19, 1932, D. MURAYAMA). Prov. Ugo: Akita (July, 1896, T. YOSHINO); Sakata (Aug. 2, 1901, G. YAMADA); Ōmagari (July 29, 1908, M. MIURA). Prov. Sado: Yoshii-mura (July 27, 1908, K. YOSHINO). Prov. Echigo: Muramatsu (July 1, 1911, K. YOSHINO); Morimachi-mura (June 23, 1910, K. YOSHINO); Kamomachi (June 8, 1908, K. YOSHINO); Mt. Yahiko (July 23, 1908, S. ITO). Prov. Musashi: Mt. Takao (Oct., 1899, S. KUSANO). Prov. Shimotsuke: Nikkō (Aug. 6, 1900, G. YAMADA & J. HANZAWA). Prov. Shinano: Mt. Asama (July 12, 1925, K. TOGASHI). Prov. Yamashiro: Kyoto (Oct. 21, 1924, K. TOGASHI). Prov. Inaba: Tottori (May 25, 1930, June 14, 1931 & Oct. 11, 1929, HIRATSUKA, f.); Ubeno-mura (May 18, 1930, HIRATSUKA, f.); Mt. Hyōnoson (Aug. 29, 1930, HIRATSUKA, f.). Prov. Tajima: Hamasaka (Nov. 5, 1929, HIRATSUKA, f.). Prov. Hōki: Mt. Daisen (June 16, 1930, HIRATSUKA, f.). Prov. Ōki: Nabewarizaka (Aug. 4, 1904, E. TOKUBUCHI). Prov. Bizen: Machikanda (July 20, 1908, I. KONDŌ). Prov. Bitchū: Kurashiki (May 25, 1930, Y. UEMURA).

*Shikoku*:—Prov. Tosa: Hane-mura (Oct., 1908, K. OGAWA); Ikku-mura (June 19, 1912, T. YOSHINAGA); Buyōji, Sako-mura (Nov., 1910, T. YOSHINAGA); Mt. Yokogura (May, 1902, T. YOSHINAGA). Prov. Iyo: Goshō-mura (June 26, 1900, K. SENGOKU); Maruho-mura (June 15, 1902, M. OKUDAIRA); Misaka-tōge (May 20, 1899, M. OKUDAIRA); Yoshida-machi (Aug. 27, 1932, K. KIMURA).

*Kiushū*:—Prov. Chikuzen: Mt. Hikosan (Sept. 3, 1934, E. TOBINAGA). Prov. Higo: Kumamoto (June 2, 1907, T. NISHIDA). Prov. Hiuga: Mt. Kirishima (July 10, 1931, T. NAITO).

*Korea*:—Prov. Keikidô: Keijô (Aug. 19, 1934, HIRATSUKA, f.).

*Formosa*:—Prov. Taihoku: Taihoku (Y. FUJIKURO).

On *Rosa Wichurariana* CREP. (*R. Luciae* FRANCH. et SAV.) (*Teriha-noibara*).

*Shikoku*:—Prov. Tosa: Irino-mura (Jan. 5, 1928, T. YOSHINAGA); Ônomi-mura (A. OYAMA).

*Honshû*:—Prov. Kii: Seto-Kanayama (Dec. 23, 1930, HIRATSUKA, f.).

On *Rosa* sp. (*Cultivated*).

*Hokkaidô*:—Prov. Ishikari: Sapporo (Oct. 7, 1924, HIRATSUKA, f.).

**Distribution.** Japan (*Hokkaidô*, *Honshû*, *Shikoku*, *Kiushû*, *Korea* and *Formosa*), China and Manchuria.

Sometimes this fungus occurs on cultivated roses, and it gives serious damage. It is one of the species common to our country and it occurs throughout Hokkaidô, Honshû, Shikoku, Kiushû, Korea and Formosa, especially on *Rosa polyantha* SIEB. et ZUCC. var. *genuina* NAKAI. It is also distributed in Northern China and Manchuria.

In 1900, DIETEL (10) reported this fungus on *Rosa multiflora* THUNB. (*R. polyantha* SIEB. et ZUCC. var. *genuina* NAKAI) which was collected by S. KUSANO at Mt. Takao (prov. Musashi) under the name of *Phragmidium subcorticium* (SCHRANK) WINT. So far as the writer knows, this was the first time the Japanese species of *Phragmidium* had been recorded.

The present fungus is nearly related to *Phragmidium mucronatum* (FR.) SCHLECHT. (*Ph. disciflorum* JAMES), but it can easily be distinguished from the latter species by the following characters. The teleutospore-septa of this fungus are larger in number than those of *Phragmidium mucronatum*. The teleutospores of the former fungus are narrower in width than those of the latter. The teleutospore pedicel of the former is yellowish brown coloured at the upper half, while that of the latter is subhyaline or pale yellow in colour.

In 1926, ABE (1) sowed aecidiospores of the present fungus from *Rosa polyantha* var. *genuina* on leaves of *Rosa Luciae* var. *fujisanensis* MAK. (*R. fujisanensis* MAK.) and *R. polyantha* var. *genuina* in Petri dishes, and obtained uredosori on the inoculated leaves of both plants.

On May 2, 1933, the writer also attempted inoculations with the aecidiospores of this fungus on *Rosa polyantha* var. *genuina* which

had been collected at Omokage-mura near Tottori on April 30, on leaves of the following species of *Rosa*; *Rosa pendulina* AIT. (*R. alpina* L.), *R. acicularis* LINDL. var. *Gmelini* SCHNEID., *R. acicularis* var. *nipponensis* HOOK. f., *R. rugosa* THUNB. and *R. polyantha* var. *genuina*. Twelve days after the inoculations, a large number of uredosori began to appear on the inoculated leaves of the control plant, *Rosa polyantha* var. *genuina* and sori developed abundantly day after day, but on the remaining plants the inoculations were unsuccessful. In the vicinity of Tottori, aecidia of this fungus begin to appear from early April to May on *Rosa polyantha* var. *genuina*. The uredosori begin to occur at early May and the teleutospores in late June. Both uredo- and teleutospores produce for a comparatively long time during the late spring to the beginning of the winter.

KASAI (42) identified the uredostage on *Rosa laevigata* MICHX. which was collected by T. YOSHINAGA in Tosa Province as the present species. In 1914, FUJIKURO (21) recorded a rust fungus on the same plant from Formosa with a new name, *Phragmidium Rosae-laevigatae* FUJIKURO, but its description has never been published in any form up to the present. The writer has the following four specimens of a *Phragmidium* on *Rosa laevigata*.

On *Rosa laevigata* MICHX. (*Naniwa-ibara*). *Shikoku*:—Prov. Tosa: Yoshiwara-goe, Nishibun-mura (Jan., 1902 & Jan., 1908, T. YOSHINAGA); Kôchi (March 19, 1934, T. YOSHINAGA). *Formosa*:—Prov. Taihoku: Shinkô (Aug. 17, 1933, Y. HASHIOKA). As these above specimens have only the uredostage, the writer can not determine whether they belong to the present species or not. The general character of this fungus on *Rosa laevigata* is as follows:—Uredosori hypophyllous, scattered or loosely grouped, minute, soon naked, somewhat pulverulent, reddish yellow in colour; paraphyses numerous, clavate or broadly clavate, 30~50  $\mu$  long, 10~18  $\mu$  wide, suberect or incurved, walls smooth, considerably thicker above and on outer side of curve, nearly colourless; uredospores globose, subglobose or broadly ellipsoidal, 18~24  $\times$  13.5~21  $\mu$ ; epispore thin, minutely echinulate.

Furthermore, the writer has a specimen of the uredostage of a *Phragmidium* on leaves of *Rosa morrisonensis* HAYATA (*Niitaka-ibara*) which was collected by Y. HASHIOKA in Mt. Niitaka, Formosa on July 10, 1933. But as this specimen lacks its teleutostage, an exact identification can also hardly be made. The general character of this Formosan fungus is as follows:—Uredosori hypophyllous,



scattered, minute, early naked, somewhat pulverulent, orange-yellow in colour; paraphyses numerous, clavate,  $50\sim75 \times 11\sim15 \mu$ , suberect or incurved, walls smooth, thicker at the apex ( $4\sim6 \mu$ ), nearly colourless; uredospores subglobose or broadly ellipsoidal,  $20\sim25 \times 15\sim21 \mu$ ; epispore  $1\sim1.5 \mu$  thick, minutely echinulate.

11. *Phragmidium mucronatum* (Fr.) SCHLECHTENDAL, Fl. Berol. II, p. 156, 1824; CUNNINGHAM in Transact. New Zealand Inst. LV, p. 16, fig. 88, 1924; Rust fungi of New Zealand; p. 123, fig. 33, 1931.

Syn. *Aegma mucronata* Fr., Observ. Myc. p. 225, 1815.

*Phragmidium subcorticium* WINT. in Pilze Deutschl. I, p. 228, 1881, p.p.; ARTHUR in N. Amer. Fl. VII, p. 172; FISCHER, Ured. Schw. p. 400, fig. 281; MC ALPINE, Rusts of Australia, p. 188, pl. I, fig. 37; pl. XXVI, figs. 229~233; SACCARDO, Syll. Fung. VII, p. 746.

*Phragmidium disciflorum* JAMES in Contrib. U. S. Nat. Herb. III, p. 276, 1895; ARTHUR in N. Amer. Fl. VII, p. 171; GROVE, Brit. Rust Fungi, p. 293, fig. 222; SYDOW, Monogr. Ured. III, p. 115.

*Phragmidium Rosae* ROSTR., Plantepat. p. 277, 1902.

*Phragmidium yezoense* (not KASAI) TAI in Nanking Jour. II, p. 176, fig. 15, 1932.

Spermogonia chiefly epiphyllous, usually few, gregarious and often somewhat confluent, inconspicuous, pale honey-yellow, flattened-conoidal or discoidal, extending into the lateral walls of the epidermal cells,  $112\sim150 \mu$  in diameter by  $35\sim40 \mu$  high. (After ARTHUR)

Aecidia hypophyllous and caulicolous, rounded or oblong,  $1\sim2.5$  mm across, usually crowded and confluent over considerable areas, on the stems sometimes  $2\sim5$  mm wide by  $5\sim18$  mm long, applanate, bright orange-yellow in colour, ruptured epidermis conspicuous; paraphyses numerous, clavate or clavate-capitate,  $45\sim80 \times 10\sim21 \mu$ , suberect or incurved, walls thin, nearly or quite colourless, smooth; aecidiospores subglobose, broadly ellipsoidal or obovate,  $21\sim30 \times 15\sim21 \mu$ ; epispore rather thick ( $2\sim3 \mu$ ), finely and distinctly verrucose. (According to European and American specimens)

Uredosori hypophyllous, scattered or gregarious, mostly thickly scattered over the whole surface of the leaves, minute, rounded,  $0.2\sim0.5$  mm across, early naked, pulverulent, orange-yellow in colour; paraphyses numerous, oblong-clavate, cylindrical or clavate,  $35\sim50 \mu$  long,  $9\sim16 \mu$  broad, strongly incurved, walls smooth, evenly



thin, colourless; uredospores subglobose, broadly ellipsoidal or obovate,  $21\sim 28 \times 15\sim 21 \mu$ ; epispore closely echinulate,  $1.8\sim 2.5 \mu$  thick; contents orange-yellow in colour.

Teleutosori hypophyllous, scattered, often thickly scattered over the whole surface, minute, early naked, pulverulent, black; paraphyses none; teleutospores cylindrical or oblong-terete,  $3\sim 7$  septate (generally 4 or 5),  $57\sim 110 \times 27\sim 36 \mu$ ; rounded at both ends, not constricted at the septa, apical papilla conical, short,  $5\sim 10 \mu$  long, subhyaline, 3 or 4 germ pores in each cell; epispore rather thick ( $4.5\sim 7 \mu$ ), closely verrucose with minute, subhyaline tubercles, dark chestnut-brown to dark brown in colour; pedicels persistent,  $60\sim 138 \mu$  long, swelling broadly clavate to subglobose, up to  $30 \mu$  at the broadest diameter, the upper half subhyaline to pale yellowish coloured, the lower half nearly or quite colourless.

**Hab.** On *Rosa* sp. (*Cultivated*).

**Honshû:**—Prov. Idzu: Itô (Nov. 5, 1933, HIRATSUKA, f.).

**Distribution.** Europe, West Asia, India, Ceylon, China, North and South America, Africa, Hawaii, Australia, New Zealand and Japan (*Honshû*).

The only specimen the writer has examined is one found by himself at Itô, Idzu Province, which has both uredospore- and teleutospore-stages. Their character corresponds exactly with that of the European form of *Phragmidium mucronatum* (FR.) SCHLECHT., and there is no doubt of their identity. This fungus is a native of Europe and is now widely distributed in almost all parts of the world on various kinds of cultivated roses. In Japan, the presence of this species has remained unknown up to this time. It was probably introduced into our country on cuttings.

It is closely related to *Phragmidium Rosae-multiflorae* DIET. Distinction between them is easily noticeable, as the writer has already described in detail under the latter species.

12. *Phragmidium fusiforme* SCHRÖTER, Brand- u. Rostpilze Schles. p. 24, 1872; Pilze Schles. p. 354; FISCHER, Ured. Schw. p. 404, fig. 283; GROVE, Brit. Rust Fungi, p. 294, fig. 223; JØRSTAD in Skrift. utgitt av Det Norske Videnskaps-Akad. Oslo, I. Matem.-Natur. Kl. (1933), no. 9, p. 60, fig. 3, 1934; KASAI in, Transact. Sapporo Nat. Hist. Soc. III, p. 31, pl. I, fig. 3, 1910; SACCARDO, Syll. Fung. VII, p. 747; SYDOW, Monogr. Ured. III, p. 121.

**Syn.** *Uredo pinguis* DC. var. *Rosae-alpinae* DC., Fl. franç. II, p. 235, 1805.

*Phragmidium Rosae-alpinae* WINT. in Pilze Deutschl. I, p. 227, 1884; PLOWRIGHT, Monogr. Brit. Ured. & Ustil. p. 226.

*Phragmidium Rosae-acicularis* LIRO, Ured. Fenn. p. 428, 1908; ARTHUR in N. Amer. Fl. VII, p. 168; SACCARDO, Syll. Fung. XXI, p. 725; SYDOW, Monogr. Ured. III, p. 120, pl. V, fig. 51. (HIRATSUKA, f. in Mem. Tottori Agric. Coll. I, p. 76, 1930; KAWAI & OTANI in Transact. Sapporo Nat. Hist. Soc. XI, p. 231, 1931).

Spermogonia not seen.

Aecidia hypophyllous or caulicolous, on leaves rounded, minute, 0.6~1.8 mm across, on nerves, petioles or stems swelling into elongate masses, up to 2 cm long, occasionally on fruits, pulvinate, finally somewhat pulverulent, orange-yellow in colour, ruptured epidermis usually conspicuous; paraphyses numerous, clavate or capitate,  $45\sim60 \times 12\sim24 \mu$ , erect or slightly incurved, walls uniformly thin,  $1 \mu$  or less, colourless, smooth; aecidiospores subglobose, broadly ellipsoidal or obovate,  $18\sim30 \times 15\sim21 \mu$ ; epispore moderately thick ( $2\sim3 \mu$ ), rather closely echinulate-verrucose, nearly or quite colourless.

Uredosori hypophyllous, scattered or grouped, minute, rounded or irregular in shape, 0.1~0.6 mm across, soon naked, pulverulent, orange-yellow in colour, ruptured epidermis rather inconspicuous; paraphyses numerous, cylindrical or clavate,  $40\sim60 \times 8\sim15 \mu$ , strongly incurved, walls thin, considerably thicker above and on outer side of curve, nearly or quite colourless, smooth; uredospores subglobose, broadly ellipsoidal or obovate,  $18\sim27 \times 15\sim21 \mu$ ; epispore moderately thin,  $1.5\sim2 \mu$  thick, closely verrucose-echinulate, subhyaline or pale yellow in colour.

Teleutosori hypophyllous, scattered or loosely grouped, minute, rounded or irregular in shape, 0.1~0.5 mm across, early naked, pulverulent, black, ruptured epidermis inconspicuous; teleutospores fusiform or fusiform-cylindrical, 8~14 septate (generally 10~12),  $42\sim114 \times 21\sim30 \mu$ , attenuate or somewhat acute at the apex, more or less rounded at the base, not constricted at the septa, uppermost cell longer than the rest, apical papilla acute, up to  $12 \mu$  long, subhyaline, 3 or 4 germ pores in each cell; epispore rather thick,  $3.5\sim5 \mu$ , closely and moderately verrucose with hyaline to subhyaline tubercles, blackish brown in colour; pedicels persistent, 60~160  $\mu$  long, the

upper part pale brownish, especially near the spore,  $9\sim12\mu$  in diameter, the lower part hygroscopic, nearly or quite colourless, in water becoming linear or somewhat oblanceolate,  $16\sim21\mu$  at the broadest diameter.

**Hab.** On *Rosa acicularis* LINDL. var. *Gmelini* C. K. SCHNEID. (*Ô-takane-bara*).

*S. Saghalien*:—Toyohara (Sept. 5, 1928, HIRATSUKA; Aug. 22, 1906, K. MIYABE & T. MIYAGI); Kashipo (Aug. 23, 1928, HIRATSUKA, f.); Horo (July 11, 1930, K. KAWAI & H. OTANI); Mt. Shiritori (Aug. 5, 1928, HIRATSUKA, f.).

*Hokkaidô*:—Prov. Iburi: Mukawa (Aug. 24, 1895, Ch. ENDO). Prov. Tokachi: Shikaribetsu-numa (July 6, 1925, HIRATSUKA, f.); Kuttari (July 7, 1926, HIRATSUKA, f.). Prov. Kushiro: Mt. Oakan (Aug. 10 & Sept. 10, 1925, HIRATSUKA, f.); Mt. Meakan (July 19, 1921, K. TOGASHI; Sept. 14, 1925 & July 13, 1928, HIRATSUKA, f.).

**Distribution.** Europe, W. Turkestan, S. Siberia, Kamtchatka, North America and Japan (*S. Saghalien* and *Hokkaidô*).

The first account of this species from our country was given by KASAI (42) in 1910 after examining the two collections on *Rosa acicularis* LINDL. var. *Gmelini* C. K. SCHNEID.; one of them was made by Ch. ENDO at Mukawa, the province of Iburi, Hokkaidô, and the other was made by T. MIYAKE at Vladimirohuka (now Toyohara), South Saghalien. These two specimens bear both its uredo- and teleutospores.

In 1930, the writer (30) reported a rust fungus on *Rosa acicularis* var. *Gmelini* which was collected by him in Mt. Shiritori, South Saghalien, as *Phragmidium Rosae-acicularis* LIRO judging from the characters of its aecidial and uredostages as well as from its host relation. In the next year, KAWAI and OTANI (44) reported *Phragmidium Rosae-acicularis* LIRO on the same plant from Horo, South Saghalien. Moreover, the SYDOWS (56) remarked as follows:—"KASAI berichtet in Transact. of the Sapporo Nat. Hist. Soc. vol. III, 1910, p. 31 über das Vorkommen dieser Art auf *Rosa acicularis* im nördlichen Japan. Wir vermuten, dass es sich hierbei nicht um *Phr. fusiforme* SCHROET., sondern um *Phr. Rosae-acicularis* LIRO handelt."

After his careful microscopical examination and field observation with a large number of specimens, the writer concludes that a *Phragmidium* on *Rosa acicularis* var. *Gmelini* found in northern

Japan is one species, and it is better to be treated as *Phragmidium fusiforme* SCHRÖT. with *Phragmidium Rosae-acicularis* LIRO as its synonym. But, a tendency seems to exist for the teleutospore-septa of the Japanese form to be more or less larger in number than those of the European form of this species on its type host, *Rosa pendulina* AIT. (*R. alpina* L.), as shown in Table 1.

TABLE 1. Number of teleutospore-septa of *Phragmidium fusiforme* SCHRÖT. on two different hosts

Hosts	Materials	Number of teleutospore-septa								
		6	7	8	9	10	11	12	13	14
<i>Rosa acicularis</i> var. <i>Gmelini</i>	Mt. Oakan, prov. Kushiro, Japan, Sept. 10, 1925, leg. HIRATSUKA, f.			4	18	24	26	18	8	2
	Mt. Meakan, prov. Kushiro, Japan, Sept. 14, 1925, leg. HIRATSUKA, f.			2	6	23	29	25	13	2
<i>Rosa pendulina</i>	French Alps, France, Sept. 1925, leg. G. MALENÇON		2	8	30	31	26	3		
	St. Graubünden, Switzer- land, Aug., 1930, leg. H. POEVERLEIN	3	14	31	42	8	2			
	Berchtesgaden, Bayer, Germany, Aug., 1928, leg. P. DIETEL		3	3	21	43	27	3		

13. *Phragmidium montivagum* ARTHUR in Torrey, IX, p. 24, text-fig. 5, 1909; N. Amer. Fl. VII, p. 169; JØRSTAD in Skrift. utgitt av Det Norske Videnskaps-Akad. Oslo, I. Matem.-Natur. Kl. (1933), no. 9, p. 60, fig. 2, 1934; SACCARDO, Syll. Fung. XXI, p. 725; SYDOW, Monogr. Ured. III, p. 129, pl. V, fig. 57.

**Syn.** *Phragmidium americanum* (not DIETEL) KASAI in Transact. Sapporo Nat. Hist. Soc. III, p. 30, pl. I, fig. 2, 1910. (HIRATSUKA, f. in Mem. Tottori Agric. Coll. I, p. 75, 1930; Transact. Sapporo Nat. Hist. Soc. IX, p. 226, 1927; KAWAI & OTANI in Transact. Sapporo Nat. Hist. Soc. XI, p. 230, 1931; TRANZSCHEL in Publ. RIABOUCHINSKY Exped., Bot. II, p. 568, 1914).

*Phragmidium yezoense* KASAI in Transact. Sapporo Nat. Hist. Soc. III, p. 35, pl. I, fig. 7, 1910; SACCARDO, Syll. Fung. XXIII, p. 821; SYDOW, Monogr. Ured. III, p. 126, pl. V, fig. 55. (HIRATSUKA, f. in Jour. Soc. Agric. & Forestr. Sapporo, XXI, p. 102, 1929; Mem. Tottori Agric. Coll. I, p. 76, 1930; KAWAI & OTANI in Transact.

Sapporo Nat. Hist. Soc. XI, p. 231, 1931; TRANZSCHEL in Publ. RIABOUCHINSKY Exped., Bot. II, p. 568, 1914).

Spermogonia amphigenous, gregarious and often confluent, in small groups surrounded by aecidia or on spots opposite the aecidia, inconspicuous, subcuticular, extending into the lateral walls of the epidermal cells, pale honey-yellow, discoidal, low,  $80\sim112\mu$  in diameter,  $30\sim35\mu$  high. (After ARTHUR, 1912).

Aecidia hypophyllous or petiolicolous, even on young shoots or fruits, rounded and minute on the leaves, elongated on the nerves of the leaves, shoots and petioles, up to 1 cm long, bright orange in colour, ruptured epidermis conspicuous; aecidiospores globose, subglobose or broadly ellipsoidal,  $18\sim27\times16\sim24\mu$ ; epispore rather thick,  $2\sim3.5\mu$ , minutely verrucose, colourless; contents orange-yellow in colour.

Uredosori hypophyllous, scattered or grouped, minute,  $0.15\sim0.4$  mm across, early naked, pulvinate, finally pulverulent, orange in colour; paraphyses numerous, cylindrical or clavate,  $35\sim60\times8\sim15\mu$ , suberect or incurved, walls uniformly thin (about  $1\mu$  thick), smooth, colourless, encircling the sorus; uredospores globose, subglobose or broadly ellipsoidal,  $20\sim25\times16\sim21\mu$ ; epispore moderately thick,  $2\sim2.8\mu$ , minutely echinulate, colourless; contents orange-yellow in colour.

Teleutosori hypophyllous or petiolicolous, scattered or gregarious, often thickly scattered over the whole surface of the leaves, often elongated on the petioles, early naked, pulverulent, black; teleutospores fusiform, subcylindrical or subclavate,  $4\sim10$  septate (generally  $6\sim8$  septate),  $51\sim111\times24\sim33\mu$ , attenuate or more or less rounded at the apex, generally rounded at the base, uppermost cell longer than the rest, not constricted at the septa,  $2\sim4$  germ pores in each cell, apical papilla conical or awl-shaped,  $5\sim14\mu$  long, pale yellow to nearly colourless; epispore  $3.8\sim5\mu$  thick, dark chocolate-brown in colour, verrucose with subhyaline tubercles; pedicels persistent,  $90\sim186\mu$  long, pale yellow in the upper part, colourless in the lower, more or less bulbous in the lower half, hygroscopic.

**Hab.** On *Rosa Marretii* LÉV. (*R. davurica* PALL.) (*Karafuto-bara*).

*S. Saghalien*:—Ôdomari (July 13, 1927, HIRATSUKA, f.); Naibuchi (July 16, 1927, HIRATSUKA, f.); Naikotoru (Aug. 16, 1907,



T. MIYAKE); Kita-Nayoshi (Aug. 27, 1929, Y. TOKUNAGA & K. KAWAI); Toyohara (Sept. 5, 1928, HIRATSUKA).

*Hokkaidô*:—Prov. Kushiro: Pirikanepu (Akan) (Sept. 9, 1925, HIRATSUKA, f.); Nanamagari (Akan) (Sept. 9, 1925, HIRATSUKA, f.); Mt. Meakan (Sept. 14, 1925, HIRATSUKA, f.); Shibbetcha (Aug. 21, 1929, HIRATSUKA). Prov. Nemuro: Naka-Shibetsu (Aug. 20, 1929, HIRATSUKA); Shunbetsu (Aug. 6, 1894, K. MIYABE).

On *Rosa rugosa* THUNB. (*Hamanasu*).

*S. Saghalien*:—Kashipo (Aug. 23, 1928, HIRATSUKA, f.); Kushunnai (Aug. 19, 1928, HIRATSUKA, f.); Sakaehama (July 15, 1927; July 28, 1928, HIRATSUKA, f.); Shisuka (Aug. 13, 1928, HIRATSUKA, f.).

*Hokkaidô*:—Prov. Oshima: Yunokawa (Oct. 28, 1922, HIRATSUKA, f.); Hakodate (Sept. 29, 1924, HIRATSUKA, f.). Prov. Shiribeshi: Zenibako (Aug. 4, 1934; Oct. 17, 1925; Oct. 9 & 31, 1924, HIRATSUKA, f.); Ranshima (Oct. 23, 1921, HIRATSUKA); Oshoro (Oct. 6, 1922, Y. HOMMA; Sept. 29, 1921, T. NAKAYAMA). Prov. Ishikari: Sapporo (Sept. 22, 1896; Oct. 6, 1894, HIRATSUKA; Sept. 9, 1921, H. TAKASUGI); Kotonî (Sept. 21, 1924, HIRATSUKA, f.). Prov. Iburi: Numanohata (Oct. 11, 1927, HIRATSUKA, f.).

*Kuriles*:—Shumushu (Sept. 22, 1892, S. YOKOYAMA).

*Honshû*:—Prov. Inaba: Suetsune (May 28, 1933, Y. UEMURA); Tottori (Dec. 4, 1933, HIRATSUKA, f.).

*Korea*:—Prov. Kankyômandô: Genzan (Aug. 21, 1934, HIRATSUKA, f.).

**Distribution.** North America, Kamtchatka, North Saghalien, Manchuria, E. Siberia and Japan (*S. Saghalien*, *Hokkaidô*, the *Kuriles*, *Honshû* and *Korea*).

In his monograph, KASAI (42) identified a rust fungus on *Rosa davurica* PALL. (*R. Marretii* LÉV.) from South Saghalien to the American species, *Phragmidium americanum* (PECK) DIET. Since then, KAWAI & OTANI (44) and the writer (27, 30) treated the same fungus on the same plant from South Saghalien and Hokkaidô as the same species.

*Phragmidium yezoense* was first described by KASAI (42) taking specimens of its teleutostage on petioles of *Rosa rugosa* THUNB. Since that time, this species has been reported by KAWAI and OTANI (44), TRANZSCHER (65) and the writer (28, 30) from various localities of North and South Saghalien, Hokkaidô, the Kuriles and Honshû, and also from Kamtchatka.

In 1934, JØRSTAD (41) who has studied the Kamtchatka rust fungi, expressed the opinion that the fungus on *Rosa Marretii* and *Phragmidium yezoense* on *Rosa rugosa* are identical morphologically, and it is treated as a collective species, *Phragmidium montivagum* ARTH. After careful examinations and comparisons of a number of specimens, the writer also thinks it better to treat the fungi on *Rosa Marretii* and *R. rugosa* as the American species, *Phragmidium montivagum*.

*Phragmidium montivagum* was first described by ARTHUR taking its type specimen on *Rosa Sayi* SCHW. which was collected at Cummings, Albany County, Wyoming, U.S.A. The present species is closely related to *Phragmidium americanum* (PECK) DIET. and *Ph. fusiforme* SCHRÖT. The teleutospores of this species in some collections much resemble those of *Phragmidium americanum*, from which it distinctly differs in the thicker walls of the aecidiospores,  $2\sim3.5\mu$  instead of  $1\sim2\mu$  thick. From *Phragmidium fusiforme* SCHRÖT., this species differs in the longer and broader teleutospores as well as fewer number of teleutospore-septa.

In 1932, TAI (59) regarded a *Phragmidium* on *Rosa rugosa* from China as *Phragmidium yezoense* KASAI. By the kindness of Prof. TAI, the writer has been able to examine the Chinese specimen. It is entirely different from this species, but it agrees with *Phragmidium mucronatum* (FR.) SCHLECHT.

14. *Phragmidium Rosae-rugosae* KASAI in Transact. Sapporo Nat. Hist. Soc. III, p. 33, pl. I, fig. 6, 1910; SACCARDO, Syll. Fung. XXIII, p. 821; SYDOW, Monogr. Ured. III, p. 123, tab. V, fig. 52. (HIRATSUKA, f. in Jour. Soc. Agric. & Forestr. Sapporo, XXI, p. 102, 1929; NAGAI & SHIMAMURA in Jour. Soc. Agric. & Forestr. Sapporo, XXV, p. 83, 1933; SYDOW in Ann. Myc. XI, p. 109, 1913; TOGASHI in Jap. Jour. Bot. II, p. 83, 1924; TOGASHI & HIRATSUKA, f. in Jour. Soc. Agric. & Forestr. Sapporo, XVI, p. 76, 1924).

**Syn.** *Phragmidium subcorticium* (not WINTER) (NAMBU in Bot. Mag. Tokyo, XXIII, p. (309), 1909, p.p.).

Spermogonia not seen.

Aecidia forming a large dense cushion on petioles, stems or fruits, and on the lower surface of leaves often causing a remarkable deformation, pulvinate, at last more or less pulverulent, bright orange-yellow in colour; paraphyses numerous, clavate,  $50\sim85\mu$  long,  $14\sim20\mu$  wide, walls smooth, uniformly thin, nearly or quite

colourless; aecidiospores subglobose, broadly ellipsoidal or somewhat angular,  $20\sim 28 \times 16\sim 22 \mu$ ; episporer minutely verrucose,  $1.8\sim 3 \mu$  thick, nearly colourless; contents orange-yellow in colour.

Uredosori hypophyllous, scattered or grouped, often thickly scattered over the whole surface of the leaves, minute, rounded or oblong,  $0.2\sim 1.6$  mm across, early naked, pulvinate, finally more or less pulverulent, orange-yellow in colour; paraphyses numerous, cylindrical or clavate,  $45\sim 75 \times 12\sim 20 \mu$ , erect or slightly incurved, walls uniformly thin, nearly or quite colourless, smooth; uredospores globose, subglobose, broadly ellipsoidal or obovate,  $20\sim 25 \times 15\sim 24 \mu$ ; episporer finely echinulate,  $1.8\sim 2.2 \mu$  thick, colourless; contents orange-yellow in colour.

Teleutosori hypophyllous, rarely on petioles, scattered or loosely aggregated, thickly scattered over the whole surface, early naked, finally pulverulent, brown to chestnut-brown in colour; teleutospores cylindrical,  $5\sim 10$  septate (generally 7),  $63\sim 128 \times 24\sim 39 \mu$ , rounded at both ends, not constricted at the septa, apical papilla obtuse (up to  $6 \mu$  long), pale yellow in colour, sometimes apical papilla entirely lacking, two end cells generally longer than the rest, 3 germ pores in each cell; episporer rather thick ( $4\sim 6 \mu$ ), light brownish yellow in colour, verrucose with subhyaline tubercles; pedicels persistent,  $60\sim 168 \mu$  long, more or less swelling at the basal part,  $18\sim 22 \mu$  at the broadest diameter, colourless or pale yellow toward the apex.

**Hab.** On *Rosa rugosa* THUNB. (*Hamanasu*).

**Hokkaidô:**—Prov. Oshima: Hakodate (Sept. 29, 1924, HIRATSUKA, f.). Prov. Shiribeshi: Shikuzushi near Otaru (Sept. 9, 1896, G. YAMADA); Zenibako (Aug. 12, 1896, HIRATSUKA & G. YAMADA; Sept. 20, 1923; Oct. 1 & 17, 1923, HIRATSUKA, f.). Prov. Tokachi: Ôtsu-mura (Sept. 17, 1927, HIRATSUKA). Prov. Ishikari: Garugawa (Sept. 2, 1926, HIRATSUKA, f.). Prov. Kitami: Noshappu-saki near Wakkanai (Oct. 15, 1923, K. TOGASHI & HIRATSUKA, f.). Prov. Nemuro: Nemuro (July 19, 1924, HIRATSUKA, f.; Sept. 10, 1927, S. IMAI).

**Kuriles:**—Etorofu (Aug. 15, 1898, T. KAWAKAMI). Kunashiri: Cape Atoiya (Aug. 3, 1929, M. NAGAI & M. SHIMAMURA).

**Honshû:**—Prov. Mutsu: Shinjô (M. MIURA); Asamushi (Sept. 15, 1926, S. ITO & HIRATSUKA, f.). Prov. Rikuchû: Noda (Oct. 10, 1910, G. YAMADA).

**Korea:**—Prov. Kankyônandô: Genzan (Aug. 21, 1934, HIRATSUKA, f.). Prov. Kôgendô: Onseiri (Soto-Kongô) (Aug. 23, 1934, HIRATSUKA, f.).

**Distribution.** Manchuria and Japan (*Hokkaidô, the Kuriles, Honshû and Korea*).

The present species is also one of the species described by KASAI (42) in 1910. From other species belonging to Sect. *Euphragmidium* on the Japanese species of *Rosa*, this species distinctly differs macroscopically in the brown to chestnut-brown coloured teleutosori, and microscopically in the general form and the colour of its teleutospores.

This fungus is widely distributed throughout Hokkaidô, the Kuriles, northern Honshû and Korea, and it is also recorded by MIURA (49) from Manchuria.

15. *Phragmidium Miyabeaenum* ITO et HIRATSUKA, f. in HIRATSUKA, f. in Ann. Myc. XXVIII, p. 279, 1930. (HIRATSUKA, f. in Transact. Tottori Soc. Agric. Sci. II, p. 242, 1931; III, p. 215, 217, 220, 221, 243, 1931; Bot. & Zool. II, p. 544, 545, 546, 1934)¹.

Spermogonia not seen.

Teleutosori amphigenous, mostly epiphyllous or petiocolous, even on peduncles or bracts, solitary or scattered, minute or medium-size, rounded or oblong, 0.6~2 mm across, soon naked, pulvinate, finally somewhat pulverulent, ruptured epidermis conspicuous, black; paraphyses none; teleutospores cylindrical, 2~6 septate (generally 4),  $52\sim90 \times 24\sim38 \mu$ , not constricted at the septa, rounded at both ends, apical papilla minute, colourless or subhyaline, sometimes wanting, 3 germ pores in each cell; epispore  $2.5\sim3.5 \mu$  thick, closely and moderately verrucose with subhyaline tubercles, olive-brown to clove brown in colour; pedicels persistent,  $72\sim150 \mu$  long,  $14\sim21 \mu$  at the broadest diameter, the lower part hygroscopic, colourless or pale yellowish coloured near the spore.

**Hab.** On *Sieversia pentapetala* GREENE (*Geum pentapetalum* MAK.) (*Chinguruma*).

*S. Saghalien*:—Mt. Tosso (July 30, 1928, HIRATSUKA, f. & S. SHIMADA); Mt. Nupuripo (July 25, 1927, HIRATSUKA, f.).

*Hokkaidô*:—Prov. Ishikari: Kumonotaira (Daisetsu-zan) (Aug. 19, 1925, K. MIYABE, HIRATSUKA, f. & I. TANAKA; Sept. 11, 1926, HIRATSUKA, f.); Mt. Kuro-dake (Sept. 12, 1926, HIRATSUKA, f., *type!*; Aug. 12, 1927, S. ITO, HIRATSUKA, f. & S. IWADARE); Mt. Kaun (Aug. 26, 1932, Y. TOKUNAGA); Mt. Tomuraushi (Aug. 27, 1932, Y. TOKUNAGA); Mt. Hokkai-dake (Aug. 14, 1927, S. ITO, HIRATSUKA, f. & S. IWADARE).

*Honshû*:—Prov. Shinano: Mt. Tsubakura (July 29 & Aug. 2, 1930, HIRATSUKA, f.) ; Mt. Komagatake (Kiso) (Aug. 9 & 11, 1931; Aug. 23, 1932, HIRATSUKA, f.).

**Distribution.** Japan (*S. Saghalien*, *Hokkaidô* and *Honshû*).

This fungus was first collected by Dr. K. MIYABE and the writer in an alpine meadow at Kumonotaira in the Daisetsu-zan Mountains in August 1925.

From *Phragmidium circumvallatum* P. MAGN. on the same genus *Sieversia* (*Geum*), the present species distinctly differs in the lack of aecidial and uredostages in its life-cycle, as well as in the absence of apical papilla of the teleutospores, their much longer pedicels and in other respects.

*Sieversia pentapetala* GREENE, which is the only known host for this fungus, has wide distribution in Kamtchatka, Maritime Province of Siberia and in South Saghalien, Hokkaidô, the Kuriles and Honshû. The present fungus has been found in the alpine regions of South Saghalien, Hokkaidô and Honshû, and it is, perhaps, also wide-spread in the Kuriles, Kamtchatka and Maritime Province of Siberia.

#### Section *Earlea* ARTHUR

##### Key to species

On *Potentilla*.

§ Eu-form.

Teleutospores 1~7 septate (generally 3 or 4).

Teleutospore pedicels long, 60~240  $\mu$  long.

16. *Phragmidium Potentillae* (PERS.) KARSTEN

Teleutospore pedicels comparatively short, 18~70  $\mu$  long.

17. *Phragmidium brevipedicellatum* HIRATSUKA, f.

Teleutospores 1~4 septate (generally 2 or 3); teleutospore pedicels 60~150  $\mu$  long.

18. *Phragmidium papillatum* DIETEL

§ -opsis-form.

Teleutospores 1~4 septate (generally 2 or 3); teleutospore pedicels 60~145  $\mu$  long.

19. *Phragmidium Itoanum* HIRATSUKA, f.

16. *Phragmidium Potentillae* (PERS.) KARSTEN, Myc. Fenn. IV, p. 49, 1878; ARTHUR in N. Amer. Fl. VII, p. 174; FISCHER, Ured. Schw. p. 410, fig. 286; GROVE, Brit. Rust Fungi, p. 291, fig. 220; PLOWRIGHT, Monogr. Brit. Ured. & Ustil. p. 221; SACCARDO, Syll.



TABLE 2. Number of teliospore-septa in the Japanese species of *Sect. Euphragmium* (200 spores measured from each material)

Species	Hosts	Materials	Number of teliospore-septa													
			2	3	4	5	6	7	8	9	10	11	12	13	14	
<i>Phragmidium alpinum</i>	<i>Rubus padalis</i>	Mt. Kuro-dake, prov. Ishikari, Sept. 11, 1926, leg. HIRATSUKA, f.														
<i>Ph. arcticum</i>	<i>R. arcticus</i>	Shizuka, S. Saghalien, Aug. 18, 1928, leg. HIRATSUKA, f.	1	3	4	9	75	93	18							
<i>Ph. arisanense</i>	<i>R. rarissimus</i>	Mt. Arisan, Formosa, Nov. 6, 1932, leg. Y. HASHIOKA			9	63	81	45	2							
<i>Ph. Miyakcanum</i>	<i>R. Kinashii</i>	Mt. Oakan, prov. Kushiro, Sept. 10, 1925, leg. HIRATSUKA, f.			2	10	23	36	91	38						
<i>Ph. Nambuwanum</i>	<i>R. Kinashii</i>	Sounkel, prov. Ishikari, Aug. 16, 1925, leg. HIRATSUKA, f.			2	23	62	82	27	4						
	<i>R. Idaeus</i> var. <i>aculeatus-sinus</i>	Boke (Akan), prov. Kushiro, Sept. 13, 1925, leg. HIRATSUKA, f.				14	31	111	42	2						
<i>Ph. Rubi-Idaei</i>	<i>R. Idaeus</i> var. <i>concolor-japonicus</i>	Mt. Kuro-dake, prov. Ishikari, Sept. 12, 1926, leg. HIRATSUKA, f.		1		4	51	86	12							
	<i>R. pseudo-japonicus</i>	Jozankei, prov. Ishikari, Sept. 25, 1927, leg. HIRATSUKA, f.				5	28	94	61	1						
<i>Ph. Rubi-japonici</i>	<i>R. Oldhami</i>	Mt. Oakan, prov. Kushiro, Sept. 10, 1926, leg. HIRATSUKA, f.			2	5	43	90	47	12	1					
<i>Ph. Rubi-Oldhami</i>	<i>R. Oldhami</i>	Morioka, prov. Rikuchū, Nov. 14, 1931, leg. Y. MAKI		5	37	102	54	2								
<i>Ph. Yamadanum</i>	<i>R. japonicus</i>	Kunimi-tōge, prov. Rikuchū, Aug. 11, 1904, leg. G. YAMADA		5	46	84	32	25	8							
	<i>R. actularis</i> var. <i>Gmelini</i>	Mt. Oakan, prov. Kushiro, Sept. 10, 1925, leg. HIRATSUKA, f.								6	23	47	55	44	21	
<i>Ph. fusiforme</i>	<i>R. Marretii</i>	Nanamagari (Akan), prov. Kushiro, Sept. 9, 1926, leg. HIRATSUKA, f.				7	10	51	99	29	4					
	<i>R. rugosa</i>	Zenibako, prov. Shiribeshi, Oct. 17, 1925, leg. HIRATSUKA, f.				5	29	85	67	14						
<i>Ph. montivagum</i>	<i>R. rugosa</i>	Yunokawa, prov. Oshima, Oct. 28, 1922, leg. HIRATSUKA, f.				2	17	35	90	49	7					
	<i>Rosa</i> sp.	Itō, prov. Idan, Nov. 5, 1933, leg. HIRATSUKA, f.		11	95	85	6	3								
<i>Ph. mucronatum</i>	<i>R. polyantha</i> var. <i>genuina</i>	Mt. Moitwa, prov. Ishikari, Aug. 13, 1924, leg. HIRATSUKA, f.				4	20	102	65	7						
<i>Ph. Rosae-multiflorae</i>	<i>R. rugosa</i>	Ôtsu-mura, prov. Tokachi, Sept. 17, 1926, leg. HIRATSUKA, f.				10	26	96	57	11						
<i>Ph. Rosae-rugosae</i>	<i>R. rugosa</i>	Mt. Kuro-dake, prov. Ishikari, Sept. 12, 1926, leg. HIRATSUKA, f.	1	32	125	41	1									
<i>Ph. Miyakeanum</i>	<i>Sieversia pentapetala</i>															

Fung. VII, p. 743; SYDOW, Monogr. Ured. III, p. 97. (DIETEL in ENGL. Bot. Jahrb. XXXVII, p. 104, 1905, p.p.; KASAI in Transact. Sapporo Nat. Hist. Soc. III, p. 29, 1910, p.p.; TOGASHI & ONUMA in Bull. Imp. Coll. Agric. & Forestr. Morioka, XVII, p. 19, 1934).

**Syn.** *Puccinia Potentillae* PERS., Syn Fung. p. 229, 1801.

*Uredo Potentillae* SCHUM., Enum. Pl. Saell. II, p. 228, 1803.

*Aregma obtusata* FR., Observ. Myc. I, p. 225, 1815, p.p.

*Phragmidium obtusum* SCHMIDT et KUNZE, Deutsch. Schwämme, V, p. 5, 1816.

*Caeoma Potentillae* SCHLECHT., Fl. Berol. II, p. 121, 1824.

Spermogonia amphigenous or on petioles, few, gregarious and often confluent, in small groups, usually surrounded by the aecidia, subcuticular, extending somewhat into the lateral walls of the epidermal cells, minute, discoidal,  $80\sim 200\ \mu$  across,  $25\sim 45\ \mu$  high, sometimes formed merely of a diffused layer of spermatophores, honey-yellow in colour; spermatia ellipsoidal or broadly ellipsoidal,  $3\sim 5.5 \times 2.5\sim 4\ \mu$ , with smooth, thin walls.

Aecidia amphigenous or petiolicolous, scattered or grouped, minute, round, ovate, oblong or irregular in shape,  $0.5\sim 2\ \text{mm}$  across, pulvinate, orange-chrome in colour, ruptured epidermis conspicuous; paraphyses cylindrical or slightly clavate, up to  $60\ \mu$  long, walls thin,  $1\ \mu$  or less, nearly or quite colourless, smooth; aecidiospores globose, broadly ellipsoidal or obovate,  $20\sim 30 \times 20\sim 27\ \mu$ ; epispore nearly colourless, moderately thin,  $1.5\sim 2\ \mu$ , rather sparsely and finely verrucose; contents orange-yellow in colour.

Uredosori hypophyllous, scattered or gregarious, rounded or irregular in shape,  $0.5\sim 1\ \text{mm}$  across, soon naked, pulverulent, ruptured epidermis not noticeable, salmon-orange in colour; paraphyses numerous, broadly clavate or capitate,  $50\sim 80 \times 12\sim 21\ \mu$ , mostly erect or slightly incurved, walls uniformly thin,  $1\ \mu$  or less, nearly or quite colourless, smooth; uredospores globose, subglobose, obovate or ellipsoidal,  $17.5\sim 27.5 \times 15\sim 25\ \mu$ ; epispore moderately thin,  $1.2\sim 2\ \mu$ , sparsely verrucose-echinulate, pale yellow in colour.

Teleutosori mostly hypophyllous or on petioles, numerous, scattered or grouped, small, rounded,  $0.5\sim 1\ \text{mm}$  across, pulvinate, early naked, ruptured epidermis conspicuous, black; paraphyses wanting; teleutospores cylindrical,  $2\sim 7$  septate,  $48\sim 90 \times 22\sim 30\ \mu$ , rounded or often somewhat acute above, usually slightly constricted

at the septa, rounded at the base, 3 germ pores in each cell; epispore  $3\sim 4\mu$  thick, sometimes thicker at the apex (up to  $10\mu$ ), smooth, olive-brown to chocolate-brown in colour; pedicels  $60\sim 240\mu$  long,  $7\sim 12\mu$  in diameter, colourless, non-hygroscopic, somewhat rugose especially at the lower part. (Pl. IV, figs. 1 & 4)

**Hab.** On *Potentilla chinensis* SER. (*Kawara-saiko*).

*Honshû*:—Prov. Rikuzen: Ishinomaki (Sept., 1897, K. KIKUCHI; Sept., 1901, HIRATSUKA). Prov. Suruga: Mt. Fuji (July 30, 1898, HIRATSUKA). Prov. Kii: Seto-Kanayama (Dec. 23, 1930, HIRATSUKA, f.). Prov. Ise: Akogigaura (Aug., 1904, T. YOSHINAGA). Prov. Inaba: Suetsune-mura (May 28, June 25, 1933, Y. UEMURA; May, 1934, HIRATSUKA, f.). Prov. Shinano: Mt. Asama (July 12, 1925, K. TOGASHI).

*Kiushû*:—Prov. Satsuma: Kagoshima (Oct. 15, 1931, T. NAITO).

*Korea*:—Prov. Kankyômandô: Genzan (Aug. 21, 1934, HIRATSUKA, f.). Prov. Kôgendô: Onseiri (Soto-Kongô) (Aug. 23, 1934, HIRATSUKA, f.). Prov. Keikidô: Seiryôri (Aug. 18, 1934, HIRATSUKA, f.)

On *Potentilla chinensis* SER. var. *littoralis* NAKAI (*Hama-saiko*).

*Korea*:—Prov. Kankyômandô: Genzan (Aug. 21, 1934, HIRATSUKA, f.).

On *Potentilla Matsumurae* WOLF. (*Miyama-kimbai*).

*Honshû*:—Prov. Mutsu: Mt. Iwaki (Sept. 11, 1898, HIRATSUKA<sup>1)</sup>; Aug. 31, 1911, G. YAMADA). Prov. Rikuchû: Mt. Hayachine (Oct. 1, 1933, K. TOGASHI & T. HORIGOME).

On *Potentilla nipponica* WOLF. (*Hiroha-no-kawarasaiko*).

*Honshû*:—Prov. Rikuchû: Mt. Himekami (June 5, 1927, K. CHIBA).

**Distribution.** Europe, North America, Siberia, Asia Minor, China, Mongolia, Manchuria and Japan (*Honshû*, *Kiushû* and *Korea*).

In the septation of teleutospores, a form on *Potentilla chinensis* SER. differs distinctly from that on *Potentilla Matsumurae* WOLF. The teleutospores of the former are  $2\sim 7$  septate (generally 4 or 5), while those on the latter form are  $2\sim 5$  septate (generally 3 or 4). But, the writer has here treated these two forms on Japanese plants, as one and the same collective species, *Phragmidium Potentillae* (PERS.) KARST., on account of the presence of many transitional

1) KASAI (42) reported this host plant as *Potentilla Dickensii* FRANCH. et SAV.

forms among them. The examination of a number of the foreign specimens of the present species stated by some authorities from widely separated localities to be distributed on many hosts, shows that there are considerable variations in the teleutospore septation as shown in Table 3.

TABLE 3. Number of teleutospore-septa of *Phragmidium Potentillae* (PERS.) KARST. on different hosts

Hosts	Materials	Number of teleutospore-septa					
		2	3	4	5	6	7
<i>Potentilla Matsumurae</i>	Mt. Iwaki, prov. Mutsu, Japan, Sept. 11, 1898, leg. HIRATSUKA	39	<b>237</b>	222	2		
<i>P. argentea</i>	Lysager near Oslo, Norway, Sept. 20, 1918, leg. I. JØRSTAD	37	<b>97</b>	59	7		
<i>P. aurea</i>	Graubünden, Switzerland, Aug. 20, 1930, leg. H. POEVERLEIN	12	<b>107</b>	75	6		
<i>P. argentea</i>	SYDOW, Myc. germ. no. 1487	20	<b>92</b>	80	8		
<i>P. arenaria</i>	Schwitzingen, Germany, Sept. 19, 1926, leg. H. POEVERLEIN	18	<b>98</b>	75	9		
<i>P. pennsylvanica</i> var. <i>strigosa</i>	SYDOW, Ured. no. 2283	7	<b>101</b>	89	3		
<i>P. argentea</i>	Speyer, Germany, Sept. 12, 1927, leg. H. POEVERLEIN	20	81	<b>90</b>	9		
<i>P. alpestris</i>	Graubünden, Switzerland, Aug., 1930, leg. H. POEVERLEIN	8	80	<b>103</b>	9		
<i>P. Hippiana</i>	SYDOW, Ured. no. 2820	4	75	<b>107</b>	14		
<i>P. argentea</i>	CONSTANTINEANU, Herb. Myc. Romaniae, no. 2800.		62	<b>106</b>	32		
<i>P. verna</i>	Dürkheim, Germany, Oct. 18, 1930, leg. H. POEVERLEIN	10	55	<b>119</b>	16		
<i>P. multifida</i>	JACZEWSKI, KOMAROV & TRANZSCHEL, Fung. Ross. no. 322	1	38	<b>120</b>	41		
<i>P. opaciformis</i>	TRANZSCHEL & SEREBRIANIKOW, Myc. Ross. no. 115	3	24	<b>86</b>	83	4	
<i>P. chinensis</i>	Seto-Kanayama, prov. Kii, Japan, Dec. 23, 1930, leg. HIRATSUKA, f.	5	42	<b>237</b>	196	19	1

As seen in the table, in the teleutospore septation, a form on *Potentilla chinensis* agrees with that on *Potentilla opaciformis*, and a form on *Potentilla Matsumurae* agrees with the European form on *Potentilla argentea* or *P. aurea*.

In Japan, the present species on *Potentilla chinensis* is rather common. At the seaside near Tottori, the aecidia associated with spermogonia begin to appear on *Potentilla chinensis* at the middle of April to May. Then the uredosori occur in early May. But, the uredosori practically disappear during the hot period of the summer months on account of high temperatures and they appear again abundantly with the teleutospores from the end of September to December.

In 1933, the writer attempted the following inoculation experiments with the aecidiospores and uredospores in order to determine the parasitism of a form of *Phragmidium Potentillae* on *Potentilla chinensis*.

A number of leaves of *Potentilla chinensis* bearing many teleutospores of this fungus, were collected by the writer at Seto-Kanayama, province of Kii on December 20, 1932. On April 10 of the next year, attempts were made to inoculate sporidia from the teleutospores on leaves of *Potentilla chinensis*, potted in the laboratory. On a number of the inoculated leaves, spermogonia were produced on April 22, and aecidia began to appear on April 26. The aecidia developed rapidly and were mature in a few days.

On April 30, inoculations were tried with the aecidiospores on the following twelve species of *Potentillinae*, viz., *Potentilla centigrana* MAXIM., *P. chinensis*, *P. fragarioides* L. var. *Sprengeliana* MAXIM., *P. Freyniana* BORUM., *P. fulgens* WALL., *P. Kleiniana* WIGHT. et ARN., *P. Miyabei* MAK., *P. nivea* L., *P. nivalis* LAPEYR., *Fragaria chiloensis* DUCH. var. *ananassa* BAILEY, *F. nipponica* MAK. and *Duchesnea indica* FOCKE. Positive results were readily secured only on the control plant, *Potentilla chinensis*, while on the remaining plants the inoculations were unsuccessful.

In the second experiment, the uredospores of this fungus which were collected by Y. UEMURA at Suetsune-mura, Inaba Province on May 28, 1933, were used as inocula. On May 30, inoculations were made on the following fourteen plants, viz., *Potentilla Dickensii* FRANCH. et SAV., *P. centigrana*, *P. chinensis*, *P. fragarioides* var. *Sprengeliana*, *P. fragarioides* var. *stolonifera*, *P. Freyniana*, *P. fulgens*, *P. Kleiniana*, *P. megalantha* TAKEDA, *P. Miyabei*, *P. nivalis*,



*P. nivea*, *Fragaria chiloensis* var. *ananassa* and *F. nipponica*. On June 14, uredosori began to appear on the inoculated leaves of the control plant, *Potentilla chinensis*, and sori developed abundantly day after day. Positive results were also obtained on *Potentilla megalantha*, but only a few uredosori were produced. No sign of infection appeared on the remaining twelve plants.

17. *Phragmidium brevipedicellatum* HIRATSUKA, f. in Transact. Sapporo Nat. Hist. Soc. XIII, p. 135, 1934. (HIRATSUKA, f. in Jour. Jap. Bot. X, p. 223, 1934).

Syn. *Phragmidium Potentillae* (not KARSTEN nor WINTER) (DIETEL in ENGL. Bot. Jahrb. XXXVII, p. 104, 1905, p.p.; Ann. Myc. VI, p. 227, 1908; HENNINGS in ENGL. Bot. Jahrb. XXXII, p. 36, 1902; KASAI in Transact. Sapporo Nat. Hist. Soc. III, p. 29, 1910, p.p.; NAMBU in Bot. Mag. Tokyo, XXIII, p. (309), fig. 3, 1909; YOSHINAGA in Bot. Mag. Tokyo, XV, p. (96), 1901; YOSHINAGA & HIRATSUKA, f. in Bot. Mag. Tokyo, XLIV, p. 649, 1930).

Spermogonia not seen.

Aecidia amphigenous, mostly hypophyllous, or petiolicolous, scattered or gregarious, small, round or ellipsoidal, 0.4~1 mm across, soon naked, pulvinate, finally somewhat pulverulent, orange chrome in colour; paraphyses wanting; aecidiospores globose, subglobose, obovate or broadly ellipsoidal,  $17.5\sim30 \times 15\sim25 \mu$ ; epispore rather thin,  $1.2\sim2 \mu$  thick, nearly colourless, densely verrucose; contents orange-yellow in colour.

Uredosori mostly hypophyllous or on petioles, peduncles or stems, scattered or loosely grouped, minute, round or oblong, 0.2~1 mm across, elongated on petioles, peduncles or stems, up to 1 cm long, soon naked, pulvinate, finally pulverulent, orange to cadmium orange in colour; paraphyses numerous, clavate or more or less capitate,  $35\sim75 \times 9\sim18 \mu$ , erect or somewhat incurved, walls smooth, uniformly thin,  $1 \mu$  or less, colourless; uredospores globose, subglobose or obovate,  $15\sim25 \times 15\sim22.5 \mu$ ; epispore minutely echinulate, thin,  $1.2\sim1.8 \mu$  thick, pale yellow or nearly colourless; contents orange-yellow in colour.

Teleutosori hypophyllous or rarely on petioles, scattered or gregarious, minute, round or oblong, 0.3~1 mm across, early naked, pulvinate, black; teleutospores cylindrical, 1~5 septate (generally 3 or 4),  $42\sim93 \times 21\sim30 \mu$ , rounded at both ends, not constricted at the septa, 3 germ pores in each cell; epispore rather thick ( $2\sim3.2 \mu$ ),

smooth, olive-brown in colour; pedicels persistent,  $18\sim70\mu$  long, non-hygroscopic, nearly or quite colourless and slightly coloured toward the upper part. (Pl. IV, figs. 2 & 5)

**Hab.** On *Potentilla Kleiniana* WIGHT. et ARN. (*O-hebi-ichigo*).

**Honshû:**—Prov. Inaba: Tottori (May 26, 1921, T. FUKUSHI; May 31 & June 5, 1933; Nov. 27, 1930, HIRATSUKA, f.); Omokage-mura (June 8, 1933 & Oct. 24, 1929, HIRATSUKA, f.); Ubeno-mura (May 18, 1930, HIRATSUKA, f.). Prov. Hôki: Daisen-mura (Nov. 11, 1929, HIRATSUKA, f.); Tokoroko-mura (Nov. 11, 1929, HIRATSUKA, f., *type!*). Prov. Iwami: Yoshida-mura (May 22, 1921, T. NAITO). Prov. Mimasaka: Yuhara-mura (Sept. 28, 1933, G. YAMADA & Y. UEMURA).

**Shikoku:**—Prov. Iyo: Ebara-mura (May 22, 1899, M. OKUDAIRA). Prov. Tosa: Kamoda-mura (May, 1903, T. YOSHINAGA); Asakura-mura (Nov., 1907, T. YOSHINAGA); Nyûgauchi, Higashigawa-mura (May, 1904, T. YOSHINAGA).

**Kiushû:**—Prov. Higo: Idzumi-mura (Jan. 3, 1907, K. YOSHINO; April 18, 1910, K. MURAKAMI); Jinnai-mura (May 11, 1907, K. YOSHINO). Prov. Bungo: Takeda-machi (June 21, 1905, K. YOSHINO).

**Distribution.** Japan (*Honshû*, *Shikoku* and *Kiushû*).

The first record of this fungus was made by HENNINGS (25) in 1902 under the name *Phragmidium Potentillae* (PERS.) KARST. based upon a specimen which was collected by T. YOSHINAGA (T. INOUE) at Sakawa-machi, the province of Tosa, Shikoku. Thereafter, it was also reported by DIETEL (16, 17), KASAI (42), YOSHINAGA (68, 71), NAMBU (51) and the writer (71) under the same name from Honshû and Shikoku.

Although the present fungus is closely related to *Phragmidium Potentillae* (PERS.) KARST., it is clearly distinguished from the latter species by its much shorter teleutospore pedicels, measuring  $18\sim70\mu$  instead of  $60\sim240\mu$ . In 1933, ARTHUR and CUMMINS (4) identified a rust fungus on *Potentilla Kleiniana* which was collected by R. R. STEWART at Poonch in the Northwest Himalayas as *Phragmidium Potentillae* (PERS.) KARST. But the writer has never been privileged to the Himalayan fungus on *Potentilla Kleiniana*, and he can not determine whether that fungus is *Phragmidium brevipedicellatum* or not.

In the neighbourhood of Tottori, the present fungus is commonly found on *Potentilla Kleiniana*, wherever the host plant is grown. The

aecidia occur in the early spring. The uredosori are produced for a comparatively long time during the early spring to the late autumn, but the sori vanish in the hot period of the summer (July and August) because of the high temperatures. The teleutospores begin to occur at the middle of September, but they develop well in the late autumn.

In 1933, the writer attempted a number of inoculation experiments in order to determine the parasitism of the present species, as related in the paragraph.

On April 18, 1933, several plants of *Potentilla Kleiniana* on which a number of aecidia of this fungus occurred on leaves, petioles or even on stems, were collected at the bank of Shin-Fukuro-gawa near the College. They were transplanted into pots and carefully cultured in the laboratory. When a large number of the aecidiospores had matured, they were used as inocula. Inoculations were made with the aecidiospores on the following fifteen plants of *Potentillinae*, viz. *Potentilla centigrana* MAXIM., *P. chinensis* SER., *P. Dickensii* FRANCH. et SAV., *P. fragarioides* L. var. *Sprengeliana* MAXIM., *P. fragarioides* var. *stolonifera* MAXIM., *P. Freyniana* BORUM., *P. fulgens* WALL., *P. Kleiniana* WIGHT. et ARN., *P. megalantha* TAKEDA, *P. Miyabei* MAK., *P. nivalis* LAPEYR., *P. nivea* L., *Fragaria chiloensis* DUCH. var. *ananassa* BAILEY, *F. nipponica* MAK. and *Duchesnea indica* FOCKE. The results of the experiments are given in the following table.

TABLE 4. Results of inoculation experiments with aecidiospores of *Phragmidium brevipedicellatum* HIRATS. f.

Plants inoculated	Date of infection	Date of first appearance of uredosori	Degree of severity
<i>Potentilla centigrana</i>	May 8, 1933		—
<i>P. chinensis</i>	May 8, 1933		—
<i>P. Dickensii</i>	May 8, 1933	May 23	++
<i>P. fragarioides</i> var. <i>Sprengeliana</i>	May 8, 1933		—
<i>P. fragarioides</i> var. <i>stolonifera</i>	May 8, 1933		—
<i>P. Freyniana</i>	May 8, 1933		—
<i>P. fulgens</i>	May 8, 1933		—
<i>P. Kleiniana</i>	May 8, 1933	May 23	+++
<i>P. megalantha</i>	May 8, 1933	May 23	++
<i>P. Miyabei</i>	May 8, 1933		—
<i>P. nivalis</i>	May 8, 1933	May 26	++
<i>P. nivea</i>	May 8, 1933	May 24	+
<i>Fragaria chiloensis</i> var. <i>ananassa</i>	May 8, 1933		—
<i>F. nipponica</i>	May 8, 1933		—
<i>Duchesnea indica</i>	May 8, 1933		—

As seen from the preceding table, infection followed with a marked development of uredosori on *Potentilla megalantha*, *P. nivalis*, *P. nivea* and the control plant, *Potentilla Kleiniana*, while on the remaining plants no sign of uredosori appeared.

In the second series of experiments, the uredospores of this fungus which were obtained from the aecidiospores in the preceding experiments were used. The inoculations were made with the uredospores on the under leaf surface of the following nine species of *Potentilla*, viz. *Potentilla centigrana*, *P. Dickensii*, *P. Kleiniana*, *P. fragarioides* var. *Sprengeliana*, *P. Freyniana*, *P. chinensis*, *P. Matsumurae* WOLF., *P. nivea* and *P. apoiensis* NAKAI. The results were recorded in the following table.

TABLE 5. Results of inoculation experiments with uredospores of *Phragmidium brevipedicellatum* HIRATS. f.

Plants inoculated	Date of infection	Date of first appearance of uredosori	Degree of severity
<i>Potentilla centigrana</i>	June 9, 1933		—
<i>P. Dickensii</i>	June 9, 1933	June 20	++
<i>P. Kleiniana</i>	June 9, 1933	June 19	+++
<i>P. fragarioides</i> var. <i>Sprengeliana</i>	June 9, 1933		—
<i>P. Freyniana</i>	June 9, 1933		—
<i>P. chinensis</i>	June 9, 1933		—
<i>P. Matsumurae</i>	June 9, 1933	June 19	+
<i>P. nivea</i>	June 9, 1933	June 19	+
<i>P. apoiensis</i>	June 22, 1933	July 3	++
<i>P. Dickensii</i>	June 22, 1933	July 5	++
<i>P. Kleiniana</i>	June 22, 1933	July 3	+++
<i>P. nivea</i>	June 22, 1933	July 4	++

From the above table, it may be seen that uredosori appeared on *Potentilla apoiensis*, *P. Dickensii*, *P. Matsumurae*, *P. nivea* and the control plant, *Potentilla Kleiniana*, while no sign occurred on the other plants.

18. *Phragmidium papillatum* DIETEL in Hedwigia XXIX, p. 25, 1890; SACCARDO, Syll. Fung. IX, p. 315; SYDOW, Monogr. Ured. III, p. 99, tab. IV, fig. 44. (HIRATSUKA, f. in Ann. Myc. XXVIII, p. 279, 1930; Jour. Jap. Bot. X, p. 225, 1934).

**Syn.** *Phragmidium Potentillae* (not KARSTEN) (KASAI in Transact. Sapporo Nat. Hist. Soc. III, p. 29, 1910, p.p.; HIRATSUKA, f. in Transact. Sapporo Nat. Hist. Soc. IX, p. 226, 1927; NAMBU in Bot. Mag. Tokyo, XXIII, p. (309), 1909).

*Phragmidium obtusum* SCHMIDT et KUNZE, f. *Potentillae strigosae* THÜM. in Bull. Soc. Imp. Nat. Moscou, LII, p. 141, 1877.

Uredosori hypophyllous, scattered or gregarious, often thickly scattered over the whole surface, minute, rounded or irregular in shape, 0.2~0.6 mm across, soon naked, pulverulent, orange in colour; paraphyses numerous, clavate, 40~65  $\times$  12~18  $\mu$ , generally slightly incurved, walls thin, about 1  $\mu$  thick, smooth, nearly or quite colourless; uredospores globose, subglobose or obovate, 18~25  $\times$  15~22  $\mu$ ; epispore 1.5~2  $\mu$  thick, verruculose, nearly colourless; contents orange-yellow in colour.

Teleutosori hypophyllous, rarely on petioles or stems, even on bracts, scattered or gregarious, sometimes thickly scattered over the whole surface of the leaves, minute, round, oblong or irregular in shape, 0.3~0.9 mm across, pulvinate, soon naked, black, ruptured epidermis conspicuous; teleutospores cylindrical, 1~4 septate (generally 3 or 2), 30~78  $\times$  21~35  $\mu$ , rounded at both ends, not constricted at the septa, apical papilla hemispherical, pale-coloured, 3 germ pores in each cell; epispore rather thick (2~3.2  $\mu$ ), smooth, olive-brown to dark olive in colour; pedicels 60~150  $\mu$  long, 10~15  $\mu$  at the broadest diameter, colourless or slightly coloured toward the upper part, non-hygroscopic, somewhat rugose especially in the lower part.

**Hab.** On *Potentilla cryptotaeniae* MAXIM. (*Mitsumoto-sô*).

**Hokkaidô:**—Prov. Oshima: Konuma (Sept. 28, 1899, K. MIYABE); Ônuma (Oct. 27, 1922, HIRATSUKA, f.); Mt. Komagatake (Sept. 28, 1924, HIRATSUKA, f.). Prov. Ishikari: Sapporo (Oct. 27, 1924, HIRATSUKA, f.); Horomui (Sept. 10, 1923, HIRATSUKA, f.). Prov. Iburi: Chitose (Oct. 10, 1927, HIRATSUKA, f.; Oct. 26, 1930, Y. IMAI; Aug. 4, 1902, K. MIYABE & S. ARIMOTO); Hayakita (Aug. 4, 1902, K. MIYABE & S. ARIMOTO). Prov. Tokachi: Makubetsu (Sept. 21, 1926, HIRATSUKA). Prov. Kushiro: Shitakara (Sept. 16, 1925, HIRATSUKA, f.); Akubetsu (Akan) (Sept. 15, 1925, HIRATSUKA, f.).

**Honshû:**—Prov. Rikuchû: Takizawa (June 2, 1909, K. SAWADA); Tashiro~Kadoma (Aug. 2, 1905, K. SAWADA); Tsunabari (May 22, 1904, K. SAWADA). Prov. Inaba: Mt. Hyônoson (Aug. 29, 1930, HIRATSUKA, f.).



*Korea*:—Prov. Kôgendô: Onseiri (Soto-Kongo) (Aug. 22, 1934, HIRATSUKA, f.).

**Distribution.** Siberia, Manchuria and Japan (*Hokkaidô*, *Honshû* and *Korea*).

The first record of the present fungus was made by THÜMEN (61) in 1877. This fungus was treated by him under the name *Phragmidium obtusum* SCHM. et KZE. f. *Potentillae strigosae* based upon a specimen on *Potentilla strigosa* LEDEB. which was collected by N. MARTIANOFF at Minussinsk, West Siberia. (THÜMEN, Myc. univ. no. 1342). In 1890, DIETEL (9) created a new species, *Phragmidium papillatum* DIET. based upon the same collection.

In Japan, this fungus on *Potentilla cryptotaeniae* MAXIM. was first recorded by NAMBU (51) in 1909 under the name *Phragmidium Potentillae* KARST. Thereafter, KASAI (42) and the writer (27) also identified it with the same species, until 1930. In that year, the writer (29) reported that the Japanese fungus on *Potentilla cryptotaeniae* is identical with the Siberian species on *Potentilla strigosa*, and that it should be called *Phragmidium papillatum* DIET.

This species closely resembles *Phragmidium Potentillae* (PERS.) KARST., from which it differs clearly in having the fewer number of teleutospore-septa, broader teleutospores and in other respects.

This is rather common in our country, especially in *Hokkaidô* and in northern and middle *Honshû*. Moreover, MIURA (49) recorded this fungus on *Potentilla cryptotaeniae* MAXIM. from Manchuria in 1928.

19. *Phragmidium Itoanum* HIRATSUKA, f. in Transact. Sapporo Nat. Hist. Soc. XIII, p. 134, 1934. (HIRATSUKA, f. in Bot. & Zool. II, p. 544, 545, 1934).

**Syn.** *Phragmidium Potentillae* (not KARSTEN) (KASAI in Transact. Sapporo Nat. Hist. Soc. III, p. 29, 1910, p.p.).

Spermogonia not seen.

Aecidia amphigenous, mostly hypophyllous, petiolicolous, or often on bracts, peduncles or on stems, scattered or gregarious, minute, round or oblong or irregular in shape, 0.3~1.5 mm across, often elongated on the nerves or petioles, up to 6 mm long, at first covered by the epidermis, then naked, pulvinate, ruptured epidermis conspicuous, bright orange-yellow in colour; paraphyses not abundant nor conspicuous, surrounding each sorus, clavate, 45~62 ×

10~16  $\mu$ , erect or slightly incurved, walls uniformly thin, 1  $\mu$  or less, smooth, nearly or quite colourless; aecidiospores globose, sub-globose, ellipsoidal or obovate, 20~32  $\times$  18~22  $\mu$ ; episporium 1.8~2.4  $\mu$  thick, minutely verrucose; contents orange-yellow in colour.

Teleutospores amphigenous or on petioles, peduncles, stems, even on bracts, scattered or solitary, small, round or oblong, 0.3~2 mm across, or elongated on petioles or peduncles, up to 9 mm long, pulvinate, finally somewhat pulverulent, ruptured epidermis conspicuous, black; teleutospores cylindrical, 1~4 septate (generally 2 or 3), 45~87  $\times$  18~27  $\mu$ ; rounded at both ends, not constricted at the septa, 2 or 3 germ pores in each cell; episporium moderately thick (2.5~3.5  $\mu$ ), thickened at the apex (up to 10  $\mu$ ), smooth, olive-brown to clove-brown in colour; pedicels persistent, 60~145  $\mu$  long, colourless, somewhat rugose especially in the lower part, non-hygroscopic. (Pl. IV, figs. 3 & 6)

**Hab.** On *Potentilla Matsumurae* WOLF. (*Miyama-kimbai*).

**Hokkaidô:**—Prov. Iburi: Mt. Makkari-nupuri (Yezo-Fuji) (Aug. 8, 1907, S. ITO<sup>1)</sup>). Prov. Ishikari: Mt. Hokkai-dake (Sept. 11, 1926, HIRATSUKA, f.); Kumonotaira (Daisetsu-zan) (Aug. 19, 1925, K. MIYABE & HIRATSUKA, f.; Sept. 11, 1926, HIRATSUKA, f. type!); Mt. Hakuun-dake (Aug. 5, 1925, HIRATSUKA, f.); Hokkai-sawa (Daisetsuzan) (Aug. 14, 1927, S. ITO, HIRATSUKA, f. & S. IWADARE); Mt. Tomuraushi (Aug., 1927, H. KATAOKA).

**Kuriles:**—Shikotan: Shakotan (Aug. 22, 1927, M. TATEWAKI).

**Honshû:**—Prov. Shinano: Mt. Yatsugatake (July 21, 1930, HIRATSUKA, f.); Mt. Tsubakura (July 29 & Aug. 2, 1930, HIRATSUKA, f.); Mt. Komagatake (Kiso) (Aug. 10 & 11, 1931; Aug. 23, 1932, HIRATSUKA, f.).

**Distribution.** Japan (*Hokkaidô*, the *Kuriles* and *Honshû*).

The present fungus closely resembles the American species, *Phragmidium biloculare* DIET. et HOLW. in its life-cycle and the host relation as well as in some morphological characters. This fungus is, however, distinguishable from the American species by the septation of the teleutospores and the characters of the teleutospore walls. The teleutospores of the Japanese fungus are generally 2 or 3 septate and their episporium is entirely smooth, while those of *Phragmidium*

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1) This specimen was identified by KASAI (42) to *Phragmidium Potentillae* (PERS.) KARST., and its host plant was recorded by him as *Potentilla gelida* C. A. MEY.

*biloculare* are mostly 1 septate (very rarely 3 septate) and their epispore is closely verrucose especially at the apex. Moreover, this species can easily be distinguished from the related species, *Phragmidium Potentillae* (PERS.) KARST. by the smaller number of teleutospore-septa as well as by its life history, lacking the uredogeneration.

This is an alpine species, and it has been found in the alpine regions of our country up to the present.

Table 6. Number of teleutospore-septa in the Japanese species of Sect. *Earlea* (500 spores measured from each material)

Species	Hosts	Materials	Number of teleutospore-septa						
			1	2	3	4	5	6	7
<i>Phragmidium Potentillae</i>	<i>Potentilla chinensis</i>	Seto-Kanayama, prov. Kii, Dec. 23, 1930, leg. HIRATSUKA, f.		5	42	237	196	19	1
	<i>P. Matsu-murae</i>	Mt. Iwaki, prov. Mutsu, Sept. 11, 1898, leg. HIRATSUKA		39	237	222		2	
<i>Ph. papillatum</i>	<i>P. cryptotaeniae</i>	Chitose, prov. Iburi, Oct. 10, 1927, leg. HIRATSUKA, f.		47	324	129			
		Mt. Komagatake, prov. Oshima, Sept. 28, 1924, leg. HIRATSUKA, f.		32	378	90			
		Lake-side of Harutori-ko, prov. Kushiro, Sept. 17, 1925, leg. HIRATSUKA, f.	1	46	301	150		2	
<i>Ph. brevipedicellatum</i>	<i>P. Kleiniana</i>	Tokoroko-mura, prov. Hôki, Nov. 11, 1929, leg. HIRATSUKA, f.	22	155	304	29			
		Asakura-mura, prov. Tosa, Nov., 1907, leg. T. YOSHINAGA	11	136	319	34			
		Omokage-mura, prov. Inaba, Nov. 27, 1930, leg. HIRATSUKA, f.	38	167	280	15			
<i>Ph. Itoanum</i>	<i>P. Matsu-murae</i>	Mt. Kuro-dake, prov. Ishikari, Sept. 11, 1926, leg. HIRATSUKA, f.	9	129	333	29			
		Kumonotaira (Daise-tsuzan), prov. Ishikari, Aug. 19, 1926, leg. HIRATSUKA, f.	22	234	241	3			

Section *Phragmotelium* (SYDOW)

## Key to species

On *Rubus*.

## § Brachy-form.

Uredospores ellipsoidal, obovate, oblong or clavate.

Uredospores comparatively large,  $24\sim45 \times 12\sim18\mu$ ; teleutospores 1~3 septate.20. *Phragmidium heterosporum* DIETELUredospores comparatively small,  $20\sim33 \times 10\sim16\mu$ ; teleutospores 1~3 septate (generally 2 or 3).21. *Phragmidium formosanum* HIRATSUKA, f.

Uredospores subglobose, broadly ellipsoidal or obovate.

Uredospores comparatively large (up to  $30\mu$  in length).Teleutospores comparatively broad ( $21\sim35\mu$ ), 2~4 septate (generally 3), germ pores in each cell generally 2.22. *Phragmidium Rubi-Thunbergii* KUSANOTeleutospores comparatively narrow ( $18\sim30\mu$ ), generally 3 or 4 septate, germ pores in each cell generally 3.Teleutospores rather thick ( $1.8\sim2.8\mu$ ), generally thickened at the apex (up to  $10\mu$ ).23. *Phragmidium griseum* DIETELTeleutospores rather thin ( $1.2\sim2\mu$ ), not or more or less thickened at the apex (up to  $4\mu$ ).24. *Phragmidium pauciloculare* (DIET.) SYDOWUredospores comparatively small,  $18\sim25 \times 10\sim16\mu$ ; teleutospores 2 or 3 septate (generally 2), rather thin ( $1.2\sim1.8\mu$ ).25. *Phragmidium Rubi-frazinifolii* SYDOWOn *Rosa*.

## § Micro-form.

26. *Phragmidium Kamtschatkae* (ANDERS.) ARTHUR et CUMMINS

20. *Phragmidium heterosporum* DIETEL in ENGL. Bot. Jahrb. XXXII, p. 626, 1903; KASAI in Transact. Sapporo Nat. Hist. Soc. III, p. 38, 1910; SACCARDO, Syll. Fung. XVII, p. 399; SYDOW, Monogr. Ured. III, p. 135. (DIETEL in Ann. Myc. VIII, p. 310, 1910; YOSHINAGA & HIRATSUKA, f. in Bot. Mag. Tokyo, XLIV, p. 649, 1930).

Uredosori hypophyllous, scattered or gregarious, minute, rounded or irregular in shape,  $0.2\sim0.4$  mm across, covered with yellowish epidermis, then naked, pulvinate, ruptured epidermis conspicuous, orange-yellow in colour; paraphyses numerous, cylindrical or clavate,  $40\sim78 \times 9\sim16\mu$ , suberect or incurved, walls colourless, thin, smooth; uredospores obovate, pyriform, oblong or clavate,  $24\sim45 \times 12\sim18\mu$ ; epispore rather thin,  $1\sim1.8\mu$  thick, minutely verrucose,

especially densely verrucose at the upper part, nearly colourless; contents orange in colour.

Teleutosori hypophyllous, scattered, minute, pulvinate, black; teleutospores cylindrical, 1~3 septate,  $47 \sim 90 \times 21 \sim 25 \mu$ , constricted at the septa, rounded at both ends; epispore smooth, brown in colour; pedicels up to  $60 \mu$  long.

**Hab.** On *Rubus trifidus* THUNB. (*Kaji-ichigo*).

*Honshû*:—Prov. Idzu: Itô (Jan. 3, 1900, S. KUSANO, *type!*).

*Shikoku*:—Prov. Tosa: Kamoda-mura (Dec., 1907, T. YOSHINAGA); Kawakita-mura (June, 1905, T. YOSHINAGA); Kôdono, Akiyama-mura (Jan., 1908, T. YOSHINAGA).

**Distribution.** Japan (*Shikoku* and *Honshû*).

This species was first described by DIETEL (12) in 1903 from a specimen on *Rubus trifidus* THUNB. which was collected by S. KUSANO at Itô, Idzu Province. The specimens the writer has examined were all in the uredostage. The above description of the teleutostage is compiled from the original.

The present fungus may be distinguished essentially from the other species of section *Phragmotelium* hitherto known by its much larger uredospores.

FUJIKURO (21) and SAWADA (54) recorded the rust fungi on *Rubus fraxinifolius* POIR. and *R. taiwanianus* MATSUM. found in Formosa as the present species. Although the writer has not been able to examine the Formosan specimens, it seems that they belong to *Phragmidium Rubi-fraxinifolii* SYD. or its related species, not to *Phragmidium heterosporum* DIET.

## 21. *Phragmidium formosanum* HIRATSUKA, f. nov. spec.

Soris uredosporiferis hypophyllis, sparsis, laxè aggregatis, minutis, mox nudis, aurantiacis; paraphysibus numerosis, cylindraceis vel clavatis,  $30 \sim 50 \times 8 \sim 12 \mu$ ; uredosporis obovatis, oblongis vel clavatis, echinulatis,  $20 \sim 33 \times 10 \sim 16.5 \mu$ ; episporio  $1 \sim 1.5 \mu$  crasso.

Soris teleutosporiferis hypophyllis, sparsis, minutis, mox nudis, atris; teleutosporis cylindraceis, 1~3-septatis (plerumque 2 vel 3), castaneo-brunneis, levibus,  $45 \sim 75 \times 18 \sim 27 \mu$ , quaque cellula poris germinationis 2 vel 3 instructa; episporio  $1.5 \sim 2.4 \mu$  crasso; pedicello persistenti, brevi, hyalino.

**Hab.** in foliis *Rubi hirsuto-pungentis* et *R. glanduloso-calycini* in Formosa, Japonia.



Uredosori hypophyllous, scattered or loosely grouped, minute, early naked, pulvinate, orange-yellow in colour; paraphyses numerous, cylindrical or clavate,  $30 \sim 50 \times 8 \sim 12 \mu$ , incurved, walls smooth, uniformly thin, nearly or quite colourless; uredospores obovate, oblong or clavate,  $20 \sim 33 \times 10 \sim 16.5 \mu$ ; epispore minutely echinulate, especially densely echinulate at the apex, thin,  $1 \sim 1.5 \mu$  thick, colourless.

Teleutosori hypophyllous, scattered, minute, early naked, black; teleutospores cylindrical,  $1 \sim 3$  septate (generally 2 or 3),  $45 \sim 75 \times 18 \sim 27 \mu$ , rounded at the apex, slightly attenuate at the base, more or less constricted at the septa, 2 or 3 germ pores in each cell; epispore smooth, rather thin,  $1.5 \sim 2.4 \mu$  thick, with a pale brownish coloured projecting papilla at the apex, chestnut-brown to dirty brown in colour; pedicels persistent, very short, colourless, non-hygroscopic.

**Hab.** On *Rubus glanduloso-calycinus* HAYATA (*Shichisei-ichigo*).

*Formosa*:—Prov. Taihoku: Mt. Nankotaizan (Takejin) (July 29, 1934, Y. HASHIOKA).

On *Rubus hirsuto-pungens* HAYATA (*Ke-sanagi-ichigo*).

*Formosa*:—Prov. Tainan: Mt. Niitaka (Shuzan) (July 10, 1933, Y. HASHIOKA, *type!*).

**Distribution.** Japan (*Formosa*).

From its related species, *Phragmidium griseum* DIET., *Ph. pauciloculare* (DIET.) SYD. and others, this species distinctly differs in the shape of the uredospores. Up to the present this species has only been collected from Formosa.

22. *Phragmidium Rubi-Thunbergii* KUSANO in Bot. Mag. Tokyo, XVIII, p. 148, 1904; KASAI in Transact. Sapporo Nat. Hist. Soc. III, p. 40, pl. I, fig. 14, 1910; SACCARDO, Syll. Fung. XXI, p. 730; SYDOW, Monogr. Ured. III, p. 137, tab. V, fig. 59. (DIETEL in ENGL. Bot. Jahrb. XXXVII, p. 104, 1905; NAMBU in Bot. Mag. Tokyo, XXIII, p. (311), fig. 7, 1909; YOSHINAGA & HIRATSUKA, f. in Bot. Mag. Tokyo, XLIV, p. 649, 1930).

**Syn.** *Phragmotelium Rubi-Thunbergii* SYDOW in Ann. Myc. XIX, p. 167, 1921.

**Exsiccati.** VESTERGREN, Micromyc. rar. sel. no. 1109.

Uredosori hypophyllous, scattered or in groups, often thickly scattered over the whole surface, minute, rounded or irregular in shape, 0.2~0.5 mm across, early naked, pulverulent, orange-yellow in colour; paraphyses numerous, cylindrical or clavate, 25~55  $\times$  9~15  $\mu$ , suberect or somewhat incurved, walls smooth, thin, nearly or quite colourless; uredospores ellipsoidal, broadly ellipsoidal or obovate, 18~27  $\times$  12~18  $\mu$ ; epispore thin, finely echinulate, nearly colourless; contents orange-yellow in colour.

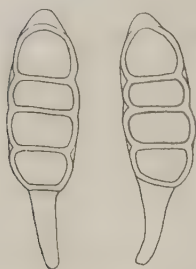


Fig. 4. Teleutospores of *Phragmidium Rubi-Thunbergii* KUSANO on *Rubus Thunbergii* SIEB. et ZUCC. (Tokyo, prov. Musashi, Oct. 30, 1904, leg. M. SHIRAI, type!).

Teleutosori hypophyllous, scattered or in irregular groups, often in uredosori, small, rounded or irregular in shape, pulvinate, yellowish brown to brownish black in colour, ruptured epidermis conspicuous; teleutospores cylindrical, 2~4 septate (generally 3), 49~85  $\times$  21~35  $\mu$ , rounded at the base, slightly attenuate at the upper end, more or less constricted at the septa, 2 germ pores (rarely 3) in each cell; epispore thin, about 2  $\mu$  thick, slightly thickened and darker at the apex, smooth, olive-brown in colour; pedicels persistent, up to 65  $\mu$  long, colourless, or subhyaline, non-hygroscopic.

**Hab.** On *Rubus Thunbergii* SIEB. et ZUCC. (*Kusa-ichigo*).

**Honshû:**—Prov. Musashi: Tokyo (Oct. 30, 1904, M. SHIRAI, type!). Prov. Sagami: Yumoto (Hakone) (Aug. 2, 1898, HIRATSUKA). Prov. Inaba: Tottori (June 21, 1931, Y. HASHIOKA).

**Shikoku:**—Prov. Tosa: Sagawa-yama, Taishô-mura (March, 1930, T. YOSHINAGA); Amatsubo-mura (June 22, 1930, T. YOSHINAGA). Prov. Iyo: Yoshida-machi (June 10, 1932, K. KIMURA).

**Kiushû:**—Prov. Satsuma: Toso near Kagoshima (May 10, 1925, T. NAITO).

**Distribution.** Japan (*Honshû*, *Shikoku* and *Kiushû*).

The present species was originally described by KUSANO (46) in 1904 taking as its type specimen a collection by M. SHIRAI in Tokyo. An opportunity to examine a part of the type material of this species has been afforded through the courtesy of Dr. KUSANO.

This species is related to *Phragmidium griseum* DIET. which it resembles very closely in both uredo- and teleutospore stages. But it differs from the latter species in the number of germ pores of the teleutospore-cell, and in the size of the teleutospores as well as in the length of the pedicels, as has already been pointed by DIETEL (16) and KASAI (42). In this fungus the germ pores in each cell are generally 2 (rarely 3), while in the case of *Phragmidium griseum* they are 3 (rarely 2 or 4). The teleutospores of this fungus are somewhat broader than those of the latter. The pedicels of this species are also always shorter than those of the latter.

23. *Phragmidium griseum* DIETEL in ENGL. Bot. Jahrb. XXXII, p. 49, 1902; KASAI in Transact. Sapporo Nat. Hist. Soc. III, p. 37, pl. I, fig. 9, 1910; SACCARDO, Syll. Fung. XVII, p. 399; SYDOW, Monogr. Ured. III, p. 135. (NAMBU in Bot. Mag. Tokyo, XXIII, p. (310), fig. 4, 1909; YOSHINAGA & HIRATSUKA, f. in Bot. Mag. Tokyo, XLIV, p. 648, 1930).

**Syn.** *Phragmidium Yoshinagai* DIET. in ENGL. Bot. Jahrb. XXXIV, p. 586, 1905; KASAI in Transact. Sapporo Nat. Hist. Soc. III, p. 41, pl. I, fig. 15, 1910; MIURA in Flora of Manchuria and East Mongolia, III, p. 377, tab. V, fig. c, 1928; SACCARDO, Syll. Fung. XXI, p. 729; SYDOW, Monogr. Ured. III, p. 137. (DIETEL in ENGL. Bot. Jahrb. XXXVII, p. 104, 1905; Ann. Myc. VI, p. 227, 1908; VIII, p. 310, 1910; HENNINGS in ENGL. Bot. Jahrb. XXXIV, p. 596, 1905; HIRATSUKA, f. in Transact. Sapporo Nat. Hist. Soc. IX, p. 226, 1927; Transact. Tottori Soc. Agric. Sci. IV, p. 38, 1932; ITO & HIRATSUKA, f. in Transact. Sapporo Nat. Hist. Soc. IX, p. 266, 1927; NAMBU in Bot. Mag. Tokyo, XXIII, p. (310), fig. 6, p. (311), 1909; SYDOW in Ann. Myc. XI, p. 109, 1913; TOGASHI & ONUMA in Bull. Imp. Coll. Agric. & Forestr. Morioka, XVII, p. 19, 1934; YOSHINAGA in Bot. Mag. Tokyo, XIX, p. (33), 1905; YOSHINAGA & HIRATSUKA, f. in Bot. Mag. Tokyo, XLIV, p. 649, 1930).

*Phragmotelium griseum* SYDOW in Ann. Myc. XIX, p. 167, 1921.

*Phragmotelium Yoshinagai* SYDOW in Ann. Myc. XIX, p. 167, 1921.

Uredosori hypophyllous, scattered or irregularly grouped, minute, rounded or irregular in shape, early naked, pulvinate, finally pulverulent, orange-yellow in colour; paraphyses cylindrical or clavate,  $30\sim70\times8\sim16\mu$ , erect or incurved, walls smooth, nearly colourless, uniformly thin,  $1\mu$  or less; uredospores subglobose,

obovate, broadly ellipsoidal or pyriform,  $18\sim30 \times 14\sim21 \mu$ ; episporium rather thin,  $1.5\sim2 \mu$  thick, densely and minutely verrucose; contents orange-yellow in colour.

Teleutospores hypophyllous, scattered or gregarious, subpulvinate, minute, rounded or irregular in shape,  $0.15\sim0.7$  mm across, soon naked, black, becoming greyish upon germination; teleutospores cylindrical,  $1\sim6$  septate (generally 3 or 4),  $30\sim85 \times 18\sim30 \mu$ , rounded or slightly attenuate at both ends, often strongly attenuate

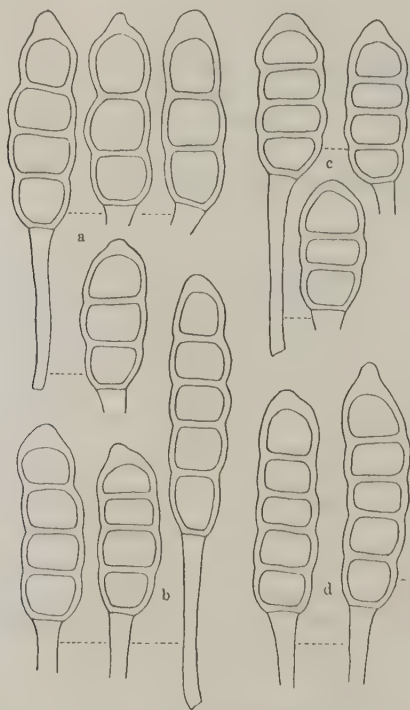


Fig. 5. Teleutospores of *Phragmidium griseum* DIET. a. Teleutospores on *Rubus microphyllus* L. f. var. *incisus* KOIDZ. (Mt. Myôgi, prov. Kôzuke, Nov. 4, 1899, leg. S. KUSANO, type!). b. Teleutospores on *Rubus microphyllus* L. f. (Agekura-mura, prov. Tosa, Dec., 1910, leg. T. YOSHINAGA). c. Teleutospores on *Rubus conduplicatus* DUTHIE (Mt. Arisan, prov. Tainan, July 13, 1933, leg. Y. HASHIOKA). d. Teleutospores on *Rubus rosaeifolius* SM. var. *tropicus* MAXIM. f. *genuinus* MAK. (Mt. Amagi, prov. Idzu, Nov. 4, 1933, leg. HIRATSUKA, f.).

at the apex, not or slightly constricted at the septa, 3 germ pores (rarely 2 or 4) in each cell; epispore  $1.8\sim 2.8\mu$  thick, thickened at the apex (up to  $10\mu$ ), chestnut-brown to dirty brown in colour, smooth; pedicels persistent, up to  $100\mu$  long,  $8\sim 16\mu$  across, colourless or subhyaline, smooth, non-hygroscopic.

**Hab.** On *Rubus conduplicatus* DUTHIE (*R. incisus* THUNB. var. *conduplicatus* KOIDZ.) (*Takasago-nigaichigo*).

*Formosa*:—Prov. Tainan: Mt. Arisan (Numanohira) (July 13, 1933, Y. HASHIOKA).

On *Rubus crataegifolius* BUNGE (*Yezo-kuma-ichigo*).

*Hokkaidô*:—Prov. Iburi: Noboribetsu (Oct. 10, 1897, G. YAMADA); Abuta (July 24, 1897, G. YAMADA); Lake-side of Shikotsu-ko (Oct. 10, 1927, HIRATSUKA, f.). Prov. Shiribeshi: Otaru (Aug. 1, 1898, G. YAMADA). Prov. Kushiro: Mt. Meakan (Sept. 14, 1925, HIRATSUKA, f.).

*Korea*:—Prov. Keikidô: Seiryôri (Aug. 18, 1934, HIRATSUKA, f.). Prov. Kôgendô: Onseiri (Soto-Kongô) (Aug. 22, 1934, HIRATSUKA, f.).

On *Rubus microphyllus* L. f. (*R. incisus* var. *geifolius* KOIDZ.) (*Koba-no-nigaichigo*).

*Shikoku*:—Prov. Tosa: Kamo-mura (Aug., 1905, T. YOSHINAGA); Agekura-mura (Dec., 1911, T. YOSHINAGA); Tokano-tôge (June, 1901, T. YOSHINAGA).

On *Rubus microphyllus* L. f. var. *incisus* KOIDZ. (*R. incisus* THUNB.) (*Nigaichigo*).

*Honshû*:—Prov. Shinano: Mt. Asama (July 12, 1925, K. TOGASHI). Prov. Kôzuke: Mt. Myôgi (Nov. 4, 1899, S. KUSANO, *type!*). Prov. Inaba: Tottori (Oct. 10, 1933, HIRATSUKA, f.). Prov. Etchû: Minakoshi (Aug., 1905, T. YOSHINAGA).

On *Rubus rosaefolius* SM. var. *tropicus* MAXIM. f. *genuinus* MAK. (*Ô-bara-ichigo*).

*Honshû*:—Prov. Idzu: Mt. Amagi (Nov. 4, 1933, HIRATSUKA, f.).

*Shikoku*:—Prov. Tosa: Yotsu-mura (Jan., 1909, T. YOSHINAGA).

On *Rubus Wrightii* A. GRAY (*R. morifolius* SIEB.) (*Kuma-ichigo*).

*Honshû*:—Prov. Mutsu: Moya-tôge (Sept. 26, 1926, S. ITO & HIRATSUKA, f.). Prov. Rikuchû: Morioka (Oct. 29, 1905, G. YAMADA & K. SAWADA; Oct. 17, 1905, K. SAWADA; Sept. 23, 1904, G. YAMADA); Takizawa (Oct. 17, 1906, G. YAMADA). Prov. Shinano: Ariake-mura



(Aug. 4, 1930, HIRATSUKA, f.); Mt. Yatsugatake (July 28, 1933, HIRATSUKA, f.). Prov. Shimotsuke: Nikkô (Aug. 6, 1900, J. HANZAWA). Prov. Suruga: Mt. Akaishi (Aug. 17, 1930, K. HARA). Prov. Inaba: Mt. Ôginosen (Oct. 27, 1929, HIRATSUKA, f.); Manisan near Tottori (Oct. 17, 1930, M. YOSHIDA); Tottori (Oct. 30, 1933, HIRATSUKA, f.). Prov. Iiôki: Daisenji (Aug. 20, 1930, G. YAMADA, T. YOSHINAGA & HIRATSUKA, f.).

*Shikoku*:—Prov. Tosa: Imai, Kagami-mura (Oct., 1908, T. YOSHINAGA); Ino-machi (Nov., 1909, T. YOSHINAGA); Mt. Yanaze (Oct., 1904, T. YOSHINAGA); Ôune, Hatayama-mura (Oct., 1903, T. YOSHINAGA, type of *Phragmidium Yoshinagai* DIET.). Prov. Iyo: Kijioku, Nibukawa-mura (Oct. 19, 1930, T. YOSHINAGA).

*Kiushû*:—Prov. Chikuzen: Mt. Hikosan (Sept. 2 & 3, 1934, E. TOBINAGA).

**Distribution.** Japan (*Hokkaidô*, *Honshû*, *Shikoku*, *Kiushû*, *Korea* and *Formosa*), Manchuria and Maritime Province of Siberia.

*Phragmidium griseum* was first described by DIETEL (11) in 1902 from a specimen on *Rubus incisus* THUNB. (*R. microphyllus* L. f. var. *incisus* KOIDZ.) which was collected by S. KUSANO at Mt. Myôgi, the province of Kôzuke on November 4, 1899. Since then, this species has been recorded by KASAI (42), YOSHINAGA and the writer (71) on *Rubus microphyllus* L. f. from the province of Tosa (*Shikoku*).

In 1905, DIETEL (16) also described a new species, *Phragmidium Yoshinagai* taking the type specimen on *Rubus morifolius* SIEB. (*R. Wrightii* A. GRAY) which was collected by T. YOSHINAGA at Hatayama-mura, the province of Tosa. Since that time, this species has been recorded by DIETEL (17, 18), HENNINGS (26), KASAI (42), NAMBU (51), the SYDOWS (57), ITO (40), YOSHINAGA (70, 71), TOGASHI & ONUMA (64) and the writer (28, 33, 40, 71) on *Rubus crataegifolius* BUNGE, *R. rosaeifolius* SM. var. *tropicus* MAXIM. f. *genuinus* MAK. (sub *Rubus sorbifolius* MAXIM. or *R. asper* WALL.) and *R. Wrightii* from various localities of Honshû, Hokkaidô and Shikoku in our country, and also on *Rubus crataegifolius* by MIURA (46) from Manchuria.

After careful examination and comparison with a large number of collections of the two species, *Phragmidium griseum* DIET. and *Ph. Yoshinagai* DIET., it is impossible to find any characters by which they could be definitely separated into distinct species. The writer has come to the conclusion that these two species should be united

as a single species, and so he has treated *Phragmidium Yoshinagai* DIET. as a synonym of *Phragmidium griseum* DIET.

Moreover, the writer also identified to this species a fungus bearing both uredo- and teleutospores on *Rubus conduplicatus* DUTHIE which was collected by Y. HASHIOKA in Formosa, as mentioned above. Recently, he also received from Prof. K. E. MURASHKINSKY of the Siberian Agricultural Academy (Omsk), a specimen of this fungus on *Rubus crataegifolius* which was collected by ZILING in the neighbourhood of Vladivostok, Maritime Province of Siberia, on July 14, 1928.

The examination of a large number of specimens of the present species on different hosts from different localities, shows that there are considerable variations in some characters, especially in the number of teleutospore-septa. There is enough difference between the extreme forms to make distinct species, if the intermediate grades did not occur. In Table 7, the results of a count of the number of teleutospore-septa from each material are shown.

TABLE 7. Number of teleutospore-septa of *Phragmidium griseum* DIET. on different hosts from different localities

Hosts	Locality	Number of teleutospore-septa	
		Range	Majority
<i>Rubus conduplicatus</i>	Mt. Arisan, Formosa	1~4	2 or 3
	Vladivostok, Russia	2~4	3
<i>R. crataegifolius</i>	Lake-side of Shikotsu-ko, prov. Iburi, Hokkaidô	2~4	3
	Mt. Meakan, prov. Kushiro, Hokkaidô	2~4	3 or 4
<i>R. microphyllus</i>	Agekura-mura, prov. Tosa, Shikoku	2~4	3
<i>R. microphyllus</i> var. <i>incisus</i>	Mt. Myôgi, prov. Kôzuke, Honshû	2~4	2 or 3
	Minakoshi, prov. Etchû, Honshû	2~4	3
<i>R. rosaeifolius</i> var. <i>tropicus</i> f. <i>genuinus</i>	Mt. Amagi, prov. Idzu, Honshû	3~6	4
	Nibukawa-mura, prov. Iyo, Shikoku	2~3	3
	Daisenji, prov. Hôki, Honshû	2~4	3
<i>R. Wrightii</i>	Ariake-mura, prov. Shinano, Honshû	2~4	3
	Manisan near Tottori, prov. Inaba, Honshû	2~5	3 or 4
	Mt. Akaishi, prov. Suruga, Honshû	3~5	4

The present species closely resembles *Phragmidium Okianum* HARA<sup>(1)</sup> and *Ph. Rubi-Thunbergii* KUSANO in the general characters. But it differs from *Phragmidium Okianum* in the number of the teleutospore-septa. The teleutospores of this species are generally 2 to 4 septate (rarely 5 or 6, very rarely 1), while in the case of the latter species they are generally 1 or 2 septate. Distinction between this species and *Phragmidium Rubi-Thunbergii* KUSANO is also easily noticeable, as the writer has already described in detail under the latter species.

24. *Phragmidium pauciloculare* (DIET.) SYDOW, Monogr. Ured. III, p. 138, tab. VI, fig. 60, 1912. (FUJIKURO in Transact. Nat. Hist. Soc. Formosa, no. 19, p. (8), 1914; HIRATSUKA, f. in Transact. Sapporo Nat. Hist. Soc. IX, p. 226, 1927; Transact. Tottori Soc. Agric. Sci. IV, p. 38, 1932; HIRATSUKA, f. & HOMMA in Jour. Soc. Agric. & Forestr. Sapporo, XIX, (no. 85), p. (76), 1927; NAGAI & SHIMAMURA in Jour. Soc. Agric. & Forestr. Sapporo, XXV, p. 83, 1933; SAWADA in Dept. Agric. Govern. Res. Inst. Formosa, Rept. no. 35, p. 35, 1928; SYDOW in Ann. Myc. XI, p. 109, 1913; TOGASHI & ONUMA in Bull. Imp. Coll. Agric. & Forestr. Morioka, XVII, p. 19, 1934; YOSHINAGA & HIRATSUKA, f. in Bot. Mag. Tokyo, XLIV, p. 649, 1930).

Syn. *Phragmidium Barnardi* (not PLOWRIGHT et WINTER) (DIETEL in ENGL. Bot. Jahrb. XXVIII, p. 285, 1900; NAMBU in Bot. Mag. Tokyo, XXIII, p. (310), fig. 5, 1909).

*Phragmidium Barnardi* PLOWR. et WINT. var. *pauciloculare* DIET. in ENGL. Bot. Jahrb. XXXII, p. 49, 1902; KASAI in Transact. Sapporo Nat. Hist. Soc. III, p. 36, pl. I, fig. 8, 1910; SACCARDO, Syll. Fung. XVII, p. 399. (DIETEL in Ann. Myc. VI, p. 227, 1908; HENNINGS in ENGL. Bot. Jahrb. XXXI, p. 732, 1902; TOKUBUCHI in MI-

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(1) *Phragmidium Okianum* HARA, Tōa-Kinrui-shi (Notes on parasitic fungi collected in Korea and Manchuria), p. 31, fig. 4, 1928. (sub *Phragmidium Okiana*)

Teleutosori hypophyllous, scattered or irregularly grouped, minute, covered by the greyish epidermis, then naked, pulvinate, black; teleutospores cylindrical, 1 or 2 septate (generally 2),  $30\sim69 \times 20\sim27\mu$ , rounded or somewhat attenuate at the apex, rounded at the base, slightly constricted at the septa, 2 or 3 germ pores in each cell; epispore  $1.5\sim2.2\mu$  thick, thickened at the apex (up to  $10\mu$ ). dirty brown in colour, smooth; pedicels up to  $115\mu$  long, nearly or quite colourless, non-hygroscopic.

Hab. On *Rubus* sp. *Manchuria*: Harbin (Sept., 1926, K. HARA, type!). The writer corrected its name to *Phragmidium Okianum* for *Ph. Okiana* by the rules of the Latin language.

YABE-Festschrift, p. (308), 1911; YOSHINAGA in Bot. Mag. Tokyo, XVI, p. (3), 1902; YOSHINO in Bot. Mag. Tokyo, XIX, p. (96), 1905).

*Phragmotelium pauciloculare* SYDOW in Ann. Myc. XIX, p. 167, 1921.

Spermogonia not seen.

Primary uredosori hypophyllous, mostly on nerves or on petioles, peduncles and buds, medium-size, rounded or irregular in shape, confluent, soon naked, pulverulent, ruptured epidermis inconspicuous, orange-yellow in colour, paraphyses none; secondary uredosori hypophyllous, scattered or gregarious, often thickly scattered over the whole surface, minute, rounded or irregular in shape, early naked, pulverulent, orange-yellow in colour; paraphyses numerous, clavate,  $38\sim60 \times 10\sim20 \mu$ , suberect or incurved, walls thin, about  $1 \mu$  thick, smooth, colourless; uredospores globose, subglobose, broadly ellipsoidal or obovate,  $15\sim25 \times 13.5\sim20 \mu$ ; epispore thin,  $1\sim2 \mu$  thick, minutely echinulate; contents orange-yellow in colour.

Teleutosori hypophyllous, scattered or irregularly grouped, often thickly scattered over the whole surface, minute, rounded,  $0.15\sim0.35$  mm across, early naked, somewhat pulverulent, brownish black to black, becoming greyish upon germination; teleutospores cylindrical to oblong-cylindrical,  $2\sim5$  septate (generally 3 or 4),  $35\sim85 \times 18\sim27 \mu$ ; rounded at both ends or often more or less attenuate at the apex, slightly constricted at the septa, apical papilla none; epispore  $1.2\sim2 \mu$  thick, slightly thickened at the apex, yellowish brown to dark brown in colour, 2 or 3 germ pores in each cell; pedicels persistent, up to  $110 \mu$  long,  $12\sim20 \mu$  at the broadest diameter, smooth, nearly colourless, non-hygroscopic. Sporidia subglobose,  $8\sim12 \mu$  in diameter, walls smooth, very thin.

**Hab.** On *Rubus parvifolius* L. (*R. triphyllus* THUNB.) (*Nawa-shiro-ichigo*).

**Hokkaidô:**—Prov. Oshima: Hakodate (July 10, 1890, K. MIYABE); Ônuma (Oct. 29, 1922, HIRATSUKA, f.); Mt. Komagatake (Sept. 28, 1924, HIRATSUKA, f.). Prov. Ishikari: Mt. Moiwa (Aug. 31 & Sept. 10, 1922; July 17 & Sept. 23, 1924; Sept. 24, 1925, HIRATSUKA, f.); Shiroishi-mura (Sept. 26, 1922, HIRATSUKA, f.); Sapporo (Aug. 14, 1890, K. MIYABE; Aug. 11, 1907, S. ITO; Sept. 9 & Nov. 9, 1894, HIRATSUKA; Oct. 20, 1897, G. YAMADA; June 5 & Oct. 10, 1906, K. MIURA; Oct. 4, 1926; Nov. 18, 1925, HIRATSUKA, f.); Maruyama (July 24, 1907, S. ITO; Oct., 1910, K. MIYABE; Oct. 20, 1923, HIRA-



TSUKA, f.) ; Mt. Teine (Oct. 19, 1924; Sept. 27, 1925, HIRATSUKA, f.; Sept. 9, 1921, H. TAKASUGI) ; Kotoni (Sept. 2, 1926, HIRATSUKA) ; Horomui (Sept. 6, 1925, HIRATSUKA, f.) ; Shinotsu (Oct. 4, 1925, HIRATSUKA, f.) ; Shimofurano (Sept. 20, 1908, M. KASAI) ; Asahikawa (Oct. 10, 1906, K. MIURA) ; Chikabumi (Sept., 1905, T. MIYAKE) ; Kamuikotan (Sept. 27, 1908, M. KASAI) ; Mt. Kurodake (Aug. 19, 1925, HIRATSUKA, f.). Prov. Shiribeshi: Shikuzushi (Otaru) (Sept. 10, 1896, G. YAMADA) ; Zenibako (Oct. 5, 1891, K. MIYABE; Aug. 20, 1899, G. YAMADA; Oct. 1 & 17, 1925, HIRATSUKA, f.). Prov. Iburi: Numanohata (Nov. 1, 1900, K. MIYABE & G. YAMADA) ; Oiwake (Oct. 30, 1900, K. MIYABE & G. YAMADA) ; Chitose (Sept. 19, 1926, HIRATSUKA, f.). Prov. Tokachi: Ôtsu-mura (Sept. 17, 1927, HIRATSUKA).

*Kuriles*.—Kunashiri: Furukamappu (M. NAGAI & M. SHIMAMURA).

*Honshû*.—Prov. Mutsu: Asamushi (Sept. 25, 1926, S. ITO & HIRATSUKA, f.) ; Goshogawara (Oct., 1904, T. KASHIWAI) ; Furumaki (Oct. 4, 1895, K. SENGOKU). Prov. Rikuchû: Morioka (Oct. 18, 1930, K. TOGASHI) ; Kii (July 20, 1932, K. TOGASHI) ; Mt. Amibari (Sept. 30, 1931, S. MURAI) ; Mt. Hayachine (July 26, 1928, K. TOGASHI). Prov. Musashi: Urawa (Nov. 15, 1899, N. NAMBU) ; Ôji (Oct. 29, 1895, K. SENGOKU) ; Tokyo (Oct. 29, 1895, K. SENGOKU). Prov. Shinano: Agematsu (Kiso) (Aug. 12, 1931, HIRATSUKA, f.) ; Mt. Asama (July 12, 1928, K. TOGASHI). Prov. Kaga: Kanazawa (June 9, 1928, HIRATSUKA). Prov. Echigo: Yahagi (July 22, 1908, S. ITO) ; Kamo (Oct. 20, 1911 & Oct. 25, 1912, K. YOSHINO). Prov. Sado: Kanasawa (July 28, 1908, K. YOSHINO). Prov. Mino: Ôgaki (Dec. 28, 1898, E. TOKUBUCHI). Prov. Tajima: Hamasaka (Nov. 5, 1929, HIRATSUKA, f.). Prov. Settsu: Kôbe (Sept. 5, 1889, K. MIYABE). Prov. Inaba: Nakanogô-mura (Nov. 3, 1929, HIRATSUKA, f.) ; Manisan near Tottori (Oct. 14, 1929, M. YOSHIDA) ; Omokage-mura (Oct. 24, 1929, M. YOSHIDA) ; Inabayama (March 26, 1930, HIRATSUKA, f.) ; Ôro-yama near Tottori (Nov. 4, 1930, HIRATSUKA, f. & Y. YOSHIDA). Prov. Hôki: Daisenji (July 2, 1924, K. TOGASHI; Aug. 23, 1929, HIRATSUKA, f.). Prov. Ōki: Kitagata (Aug. 5, 1907, E. TOKUBUCHI) ; Saigô (July 6, 1924, K. TOGASHI).

*Shikoku*.—Prov. Tosa: Kamoda-mura (Dec., 1907, T. YOSHINAGA) ; Kawakita-mura (June, 1905, T. YOSHINAGA). Prov. Iyo: Takakushi (May 28, 1932, K. KIMURA) ; Maruho-mura (June 17, 1902, K. OKUDAIRA).



*Kiushû*:—Prov. Chikuzen: Mt. Hikosan (Sept. 3, 1934, E. TOBINAGA). Prov. Higo: Mt. Aso (July 4, 1932, Y. HASHIOKA). Prov. Hiuga: Mt. Kirishima (July 10, 1931, T. NAITO). Prov. Satsuma: Toso near Kagoshima (Nov. 12, 1924, T. NAITO).

*Korea*:—Prov. Kankyômandô: Genzan (Aug. 21, 1934, HIRATSUKA, f.). Prov. Kôgendô: Onseiri (Soto-Kongô) (Aug. 23, 1934, HIRATSUKA, f.). Prov. Keikidô: Seiryôri (Aug. 18, 1934, HIRATSUKA, f.).

*Formosa*:—Prov. Taihoku: Taihoku (Y. FUJIKURO).

On *Rubus parvifolius* L. var. *concolor* (KOIDZ.) MAKINO et NEMOTO.

*Honshû*:—Prov. Tajima: Hamasaka (Nov. 5, 1929, HIRATSUKA, f.).

On *Rubus phoenicolasius* MAXIM. (*Urajiro-ichigo*).

*Hokkaidô*:—Prov. Ishikari: Toyohira near Sapporo (Oct. 8, 1894, HIRATSUKA); Mt. Moiwa (Oct. 10, 1922, HIRATSUKA, f.); Maruyama (Oct. 23, 1920, K. TOGASHI). Prov. Shiribeshi: Zenibako (Oct. 20, 1899, G. YAMADA).

*Honshû*:—Prov. Rikuchû: Samuraihama (Oct. 17, 1910, G. YAMADA); Yanagawa (Nov. 12, 1905, K. SAWADA). Prov. Suruga: Mt. Akaishi (Aug. 17, 1930, K. HARA).

*Shikoku*:—Prov. Tosa: Kawakita-mura (Jan. 3, 1914, T. YOSHINAGA); Okomiyama (July 14, 1927, T. YOSHINAGA). Prov. Iyo: Iradzu-yama (Oct. 17, 1930, T. YOSHINAGA).

**Distribution.** Japan (*Hokkaidô*, the *Kuriles*, *Honshû*, *Shikoku*, *Kiushû*, *Korea* and *Formosa*), China and Manchuria.

The first account of this fungus was given by DIETEL (10) in 1900 after examining a specimen of the uredostage on *Rubus parvifolius* L. collected by S. KUSANO at Sôma, Iwaki Province. At that time, he identified it with some doubt to the Australian species, *Phragmidium Barnardi* PLOWR. et WINT. In 1902, he (11) treated it as a variety of the Australian species, *Phragmidium Barnardi* var. *pauciloculare* DIET. The chief point of difference between them was recognized in the septation of the teleutospores. The teleutospores of this fungus are 2~5 septate (generally 3 or 4), while those of *Phragmidium Barnardi* PLOWR. et WINT. are 5~8 septate (generally 6). In 1912, the SYDOWS (56) raised this fungus to specific rank.

This species also resembles *Phragmidium griseum* DIET., from which it can easily be distinguished macroscopically by its very

minute teleutosori and microscopically by some characters of the teleutospores. The teleutospores of this fungus are rather thin-walled ( $1.2\sim 2\mu$ ), and either not or more or less thickened at the apex (up to  $4\mu$ ), while those of *Phragmidium griseum* are comparatively thick ( $1.8\sim 2.8\mu$ ), and generally thickened at the apex (up to  $10\mu$ ). Moreover, a tendency seems to exist for the uredospores of this species to be more or less smaller than those of the latter fungus.

In our country, this fungus is very widely distributed, extending from the Kuriles to Formosa.

25. *Phragmidium Rubi-fraxinifolii* SYDOW in Ann. Myc. XII, p. 107, 1914; SACCARDO, Syll. Fung. XXIII, p. 824. (SAWADA in Agric. Exper. Stat. Govern. Formosa, Sp. Bull. XIX, p. 379, 1919).

Soris teleutosporiferis hypophyllis, sparsis vel aggregatis, minutis, punctatis, rotundatis, mox nudis, atris; teleutosporis oblongo-cylindraceis. 2- vel 3-septatis (plerumque 2), olivaceo-brunneis, levibus,  $40\sim 60\times 21\sim 27\mu$ , quaque cellula poris germinationis 3 instructis; episporio  $1.2\sim 1.8\mu$  crasso; pedicello persistenti, usque  $60\mu$  longo, hyalino.

**Hab.** in foliis *Rubi fraxinifolii* in Formosa, Japonia.

Uredosori hypophyllous, scattered or gregarious, minute, punctate, early naked, orange-yellow in colour; paraphyses numerous, clavate,  $35\sim 50\times 8\sim 12\mu$ , suberect or incurved, walls smooth, colourless, uniformly thin; uredospores subglobose, obovate or broadly ellipsoidal,  $18\sim 25\times 10\sim 16\mu$ ; episporium thin ( $1\sim 1.5\mu$ ), minutely echinulate, nearly colourless.

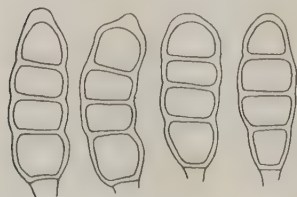


Fig. 6. Teleutospores of *Phragmidium Rubi-fraxinifolii* SYD. on *Rubus fraxinifolius* POIR. (Mt. Arian, prov. Tainan, July 6, 1933, leg. Y. HASHIOKA).

Teleutosori hypophyllous, scattered or grouped, minute, punctate, rounded or irregular in shape, early naked, black; teleutospores oblong-cylindrical, 2 or 3 septate (generally 2),  $40\sim 60\times 21\sim 27\mu$ , rounded or attenuate at both ends, more or less constricted at the septa, 3 germ pores in each cell; episporium smooth, rather thin ( $1.2\sim 1.8\mu$ ), slightly thickened at the apex, olive-brown in colour; pedicels persistent, short, up to  $60\mu$  long, colourless, non-hygroscopic.

**Hab.** On *Rubus fraxinifolius* POIR. (*Tonerikoba-no-ichigo*).

*Formosa*:—Prov. Tainan: Mt. Arisan (Numanohira) (July 6, 1933, Y. HASHIOKA, *type of teleutostage!*).

**Distribution.** Japan (*Formosa*).

The first description of this species was made by the SYDOWS (58) in 1914 based upon a specimen of the uredostage on *Rubus fraxinifolius* POIR. which was collected by R. SUZUKI from Formosa.

Recently, the writer has received from Mr. HASHIOKA a specimen of the fungus on the same plant collected by him in Mt. Arisan, Formosa. This collection bears both uredo- and teleutospores, and the fungus belongs to a species of sect. *Phragmotelium*. Although the writer has not been to examine an authentic specimen of *Phragmidium Rubi-fraxinifolii* SYD. for comparison, the uredostage of HASHIOKA's collection agrees exactly with its original description, and the writer treated here the fungus under consideration as the present species.

The writer also has in his herbarium the following specimens of the uredostage of a *Phragmidium* on the five species of *Rubus*: *Rubus euphlebophyllus* HAYATA, *R. glanduloso-punctatus* HAYATA, *R. palmatus* THUNB. var. *palmatus* O. KUNTZE, *R. parviaraliifolius* HAYATA and *R. taiwanianus* MATSUM.

On *Rubus euphlebophyllus* HAYATA (*Yômyaku-ichigo*).

*Formosa*:—Prov. Taihoku: Yappitsu (April 15, 1933, T. SUZUKI).

On *Rubus glanduloso-punctatus* HAYATA (*Sakuma-ichigo*).

*Formosa*:—Prov. Taihoku: Mt. Nankotaizan (Kirettoi) (July 27, 1934, Y. HASHIOKA).

On *Rubus palmatus* THUNB. var. *palmatus* O. KUNTZE (*Nagabano-momiji-ichigo*).

*Kiushû*:—Prov. Chikuzen: Mt. Hôman (Aug. 27, 1931, O. ISHII-UCHI). Prov. Ôsumi: Mt. Takakuma (July 26, 1926, T. NAITO).

On *Rubus parviaraliifolius* HAYATA (*Taraba-ichigo*).

*Formosa*:—Prov. Taihoku: Ekijyû (July 30, 1934, Y. HASHIOKA).

On *Rubus taiwanianus* MATSUM. (*Taiwan-ichigo*).

*Formosa*:—Prov. Taihoku: Bokusaku (April 23, 1933, Y. HASHIOKA); Kussaku (April 30, 1933, Y. HASHIOKA).

Although the teleutospores have been seen, the fungi on these specimens seem to be the uredostage of *Phragmidium Rubi-fraxinifolii* SYD. or its related species.

26. *Phragmidium Kamtschatkae* (ANDERS.) ARTHUR et CUMMINS in Mycologia XXV, p. 401, 1933; HIRATSUKA, f. in Jour. Jap. Bot. X, p. 4, 1934; JØRSTAD in Skrift. utgitt av Det Norske Videnskaps-Akad. Oslo, I. Matem.-Natur. Kl. (1933), no. 9, p. 67, 1934.

**Syn.** *Caeoma (Uredo) Rosae?* SCHLECHT. in NEES v. ESENB., Horae Physicae Berol., p. 90, 1820.

*Puccinia Rosae* BARCL. in Jour. Asiatic Soc. Bengal, LVIII, pt. II, p. 233, tab. XII, figs. 6~8, 1889; IDETA, Handb. Pl. Diseases, Japan, 4 ed., p. 534, fig. 193, 1911; SACCARDO, Syll. Fung. IX, p. 299; SYDOW, Monogr. Ured. I, p. 487. (not *Puccinia Rosae* SCHUM., Enum. Pl. Saell. II, p. 235, 1803).

*Puccinia Kamtschatkae* ANDERS. in Jour. Myc. VI, p. 125, 1891; SACCARDO, Syll. Fung. IX, p. 306.

*Gymnoconia Rosae* LIRO, Ured. Fenn. p. 413, 1908; SYDOW, Monogr. Ured. III, p. 82. (HIRATSUKA, f. in Mem. Tottori Agric. Coll. I, p. 77, 1930).

*Phragmidium Rosae* TRANZSCH. in Publ. RIABOUCHINSKY Exped., Bot. II, p. 564, 1914. (not *Phragmidium Rosae* ROSTR., Plantepat. p. 277, 1902).

*Teloconia Rosae* SYDOW in Ann. Myc. XIX, p. 168, 1921.

Spermogonia epiphyllous, numerous, punctate, irregularly and closely aggregated or scattered, minute, at first honey-yellow, then reddish brown in colour; spermatia globose or ovate, colourless.

Teleutosori amphigenous or stipules, thickly developed over the whole surface of the leaves, early naked, confluent, somewhat pulverulent, rust-coloured, ruptured epidermis conspicuous; teleutospores ellipsoidal, oblong or oblong-ellipsoidal, 1 septate (rarely 2),  $30 \sim 50 \times 16 \sim 35 \mu$ , rounded at the apex, rounded or somewhat attenuate at the base, slightly constricted at the septum, 2 or 3 germ pores (generally 2) in each cell; epispore uniformly thin, yellow, with 3 to 5 rows of warts; pedicels persistent, very short. This fungus causes witches' broom on host plant.

**Hab.** On *Rosa Marretii* LÉV. (*R. davurica* PALL.) (Karafuto-bara).

*S. Saghaliensis*:—Ôsaka (July 1, 1906, T. MIYAKE); Tei'ya (July 4, 1906, T. MIYAKE).

On *Rosa rugosa* THUNB. (*Hamanasu*).

*S. Saghaliensis*:—Sakaehama (July 15, 1927, HIRATSUKA, f.).

*Hokkaidô*:—Prov. Shiribeshi: Zenibako (June 24, 1926 & May 8, 1927, HIRATSUKA, f.). Prov. Ishikari: Ishikari (June, 1896, T. KAWAKAMI; May 31, 1897, K. MIYABE; May 20, 1924, HIRATSUKA, f.); Sapporo (May 29, 1906, K. MIURA).

*Kuriles*:—Etorofu: Tokochan (July 17, 1906, K. MIURA).

**Distribution.** Northern Europe (*Finland* and *N. Russia*), Caucasus, Himalaya, W. Turkestan, S. Siberia, Manchuria, Kamchatka and Japan (*S. Saghalien*, *Hokkaidô* and *the Kuriles*).

The first study of the present fungus in Japan was made by G. YAMADA, who in 1898 described his exhaustive studies of this fungus on *Rosa rugosa* THUNB. in Hokkaidô in his graduation thesis, entitled, "On witches' brooms of *Rosa rugosa* (*Hama-nasu*)" (In *Japanese*), prepared under the direction of Prof. MIYABE in the Botanical Laboratory, Sapporo Agricultural College, but that paper was never published in its original form. However, in his manual, IDETA (39) described this fungus on *Rosa rugosa* chiefly based upon YAMADA's manuscript. This is the first record of the present fungus from our country.

As far as the writer knows, this fungus is found in Japan only from South Saghalien, Hokkaidô and the Kuriles.

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#### Excluded species

*Phragmidium carbonarium* (SCHLECHT.) WINT.—*Xenodochus carbonarius* SCHLECHT. (*Linnaea* I, p. 237, 1826).

*Phragmidium japonicum* DIET.—*Kuchneola japonica* DIET. (*Ann. Myc.* X, p. 205, 1912).

*Phragmidium Rubi-Sieboldi* KAWAGOE—*Hamasporea Rubi-Sieboldi* (KAWAGOE) DIET. (*Ann. Myc.* XX, p. 293, 1922).

#### Distribution of the Japanese species of *Phragmidium*

The Japanese species of *Phragmidium* are distributed in regions other than Japan as shown in the following table. The first column of the table gives the name of the species, the second column to the sixth shows the distribution of each species in different parts of our country, and the last nine columns indicate the distribution in other regions of the world.



TABLE 8. Distribution of Japanese species of *Phragmidium*

Species	Regions										
	S. Saghalien	Kuriles	Hokkaidō	Honshū	Shikoku & Kiushū	Korea	Formosa	Northern China, Manchuria & Amur-region	Kamtschatka	Siberia	Southern China, India & Philippines
Sect. <i>Euphragmidium</i>											
<i>Phragmidium</i>											
<i>Rubi-japonici</i>	+	+	+	+					+	+	
<i>Ph. arcticum</i>	+	+	+	+	+	+	+	+	+	+	+
<i>Ph. Rubi-Idaei</i>	+	+	+	+	+	+	+	+	+	+	+
<i>Ph. Rubi-Oldhami</i>	+	+	+	+	+	+	+	+	+	+	+
<i>Ph. Miyakeanum</i>	+	+	+	+	+	+	+	+	+	+	+
<i>Ph. Nambuianum</i>	+	+	+	+	+	+	+	+	+	+	+
<i>Ph. arisanense</i>	+	+	+	+	+	+	+	+	+	+	+
<i>Ph. Yamadanum</i>	+	+	+	+	+	+	+	+	+	+	+
<i>Ph. alpinum</i>	+	+	+	+	+	+	+	+	+	+	+
<i>Ph. Rosae-multiflorae</i>	+	+	+	+	+	+	+	+	+	+	+
<i>Ph. mucronatum</i>	+	+	+	+	+	+	+	+	+	+	+
<i>Ph. fusiforme</i>	+	+	+	+	+	+	+	+	+	+	+
<i>Ph. montivagum</i>	+	+	+	+	+	+	+	+	+	+	+
<i>Ph. Rosae-rugosae</i>	+	+	+	+	+	+	+	+	+	+	+
<i>Ph. Miyabeianum</i>	+	+	+	+	+	+	+	+	+	+	+
Sect. <i>Earlea</i>											
<i>Ph. Potentillae</i>	+	+	+	+	+	+	+	+	+	+	+
<i>Ph. brevipedicellatum</i>	+	+	+	+	+	+	+	+	+	+	+
<i>Ph. papillatum</i>	+	+	+	+	+	+	+	+	+	+	+
<i>Ph. Itoanum</i>	+	+	+	+	+	+	+	+	+	+	+
Sect. <i>Phragmotelium</i>											
<i>Ph. heterosporum</i>	+	+	+	+	+	+	+	+	+	+	+
<i>Ph. formosanum</i>	+	+	+	+	+	+	+	+	+	+	+
<i>Ph. Rubi-Thunbergii</i>	+	+	+	+	+	+	+	+	+	+	+
<i>P. griseum</i>	+	+	+	+	+	+	+	+	+	+	+
<i>Ph. pauciloculare</i>	+	+	+	+	+	+	+	+	+	+	+
<i>Ph. Rubi-fraxinifolia</i>	+	+	+	+	+	+	+	+	+	+	+
<i>Ph. Kamtschatkae</i>	+	+	+	+	+	+	+	+	+	+	+
Total	8	6	15	18	7	7	6	9	5	5	1
											6
											5
											1
											1
											1
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BOTANICAL LABORATORY,  
TOTTORI AGRICULTURAL COLLEGE,  
TOTTORI, JAPAN

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## PLATE III

Fig. 1. Teleutosori of *Phragmidium Kamtschatkae* (ANDERS.) ARTH. et CUMM. on *Rosa rugosa* THUNB. (Zenibako, prov. Shiribeshi, June 24, 1926, leg. HIRATSUKA, f.).

Fig. 2. Teleutosori of *Phragmidium alpinum* HIRATS. f. on *Rubus pedatus* SM. (Mt. Tsubakura, prov. Shinano, Aug. 2, 1930, leg. HIRATSUKA, f.).

Fig. 3. Teleutosori of *Phragmidium Nambuianum* DIET. on *Rubus Kinashii* LÉV. et VNT. (Sôunkei, prov. Ishikari, Aug. 16, 1925, leg. HIRATSUKA, f.).

Fig. 4. Teleutosori of *Phragmidium Rubi-japonici* KASAI on *Rubus pseudo-japonicus* KOIDZ. (Mt. Oakan, prov. Kushiro, Sept. 10, 1925, leg. HIRATSUKA, f.).

Fig. 5. Teleutosori of *Phragmidium Rubi-Idaei* (DC.) KARST. on *Rubus Idaeus* L. var. *aculeatissimus* RGL. et TIL. (Shitakara, prov. Kushiro, Sept. 13, 1925, leg. HIRATSUKA, f.).

Fig. 6. Teleutosori of *Phragmidium pauciloculare* (DIET.) SYD. on *Rubus parvifolius* L. (Toyohira near Sapporo, prov. Ishikari, Oct. 4, 1926, leg. HIRATSUKA, f.).

## PLATE IV

Fig. 1. Uredospores of *Phragmidium Potentillae* (PERS.) KARST. on *Potentilla chinensis* SER. (Tottori, prov. Inaba, July 22, 1933, leg. Y. UEMURA).  $\times 530$ .

Fig. 2. Uredospores of *Phragmidium brevipedicellatum* HIRATS. f. on *Potentilla Kleiniana* WIGHT. et ARN. (Tottori, prov. Inaba, Aug. 5, 1933, leg. Y. UEMURA).  $\times 530$ .

Fig. 3. Aecidiospores of *Phragmidium Itoanum* HIRATS. f. on *Potentilla Matsu-murae* WOLF. (Kumonataira, Daisetsu Mountains, prov. Ishikari, Aug. 19, 1925, leg. K. MIYABE & HIRATSUKA, f.).  $\times 530$ .

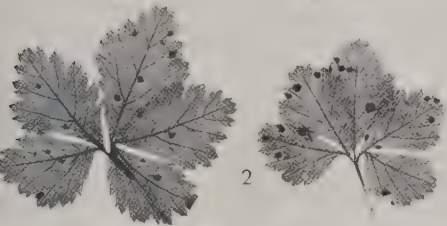
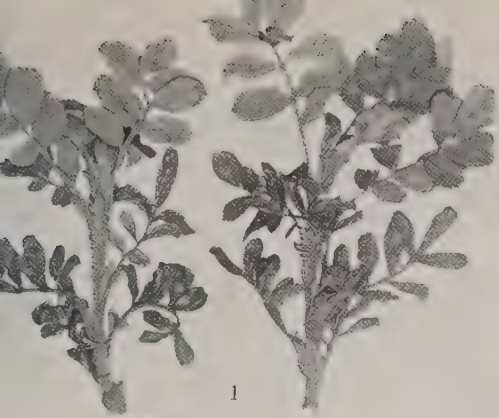
Fig. 4. Teleutospores of *Phragmidium Potentillae* (PERS.) KARST. on *Potentilla chinensis* SER. (Seto-Kanayama, prov. Kii, Dec. 23, 1930, leg. HIRATSUKA, f.).  $\times 530$ .

Fig. 5. Teleutospores of *Phragmidium brevipedicellatum* HIRATS. f. on *Potentilla Kleiniana* WIGHT. et ARN. (Tokoroko-mura, prov. Hôki, Nov. 11, 1929, leg. HIRATSUKA, f.).  $\times 530$ .

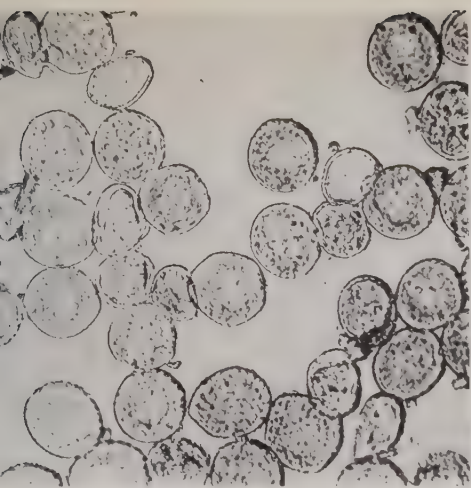
Fig. 6. Teleutospores of *Phragmidium Itoanum* HIRATS. f. on *Potentilla Matsu-murae* WOLF. (Hokkai-sawa, Daisetsu Mountains, prov. Ishikari, Aug. 14, 1927, leg. S. ITO, HIRATSUKA, f. & S. IWADARE).  $\times 530$ .







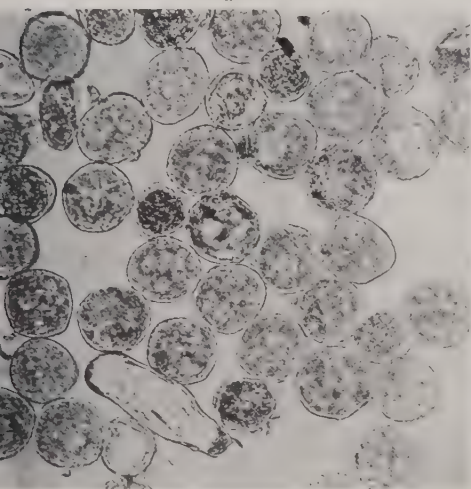




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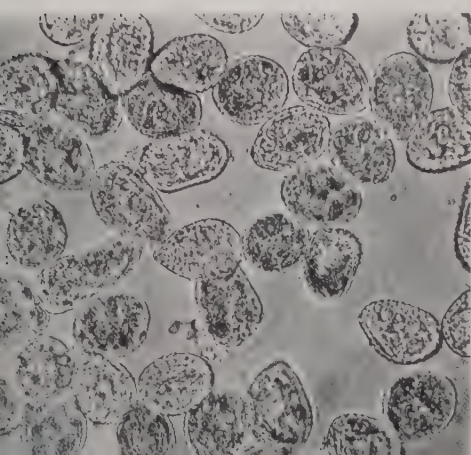
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# Karyogenetische Studien bei reinen Arten und Bastarden der Emmerreihe I. Reifungsteilungen<sup>(1)</sup>

Von Sigeo HOSONO

Hierzu 6 Textabbildungen

(Eingegangen am 6. November, 1934)

## I. Einleitung

Aus einer Reihe von Arbeiten über *Triticum* ist zu entnehmen, dass in den Reifungsteilungen der reinen Arten und der Bastarde innerhalb jeder der beiden polyploiden Reihen—Emmer und Dinkel—kleine Unregelmässigkeiten vorkommen. Die bis zum Jahre 1929, in dem ich meine Studien begonnen habe, vorliegenden Angaben beziehen sich ausschliesslich auf die *vulgare*-Gruppe, die begreiflicherweise mehr im Vordergrund des Interesses stand als die Emmerreihe. Sie finden sich vor allem bei GOULDEN (1925), ELDERS (1927), THOMPSON (1928) und SAPÉHIN (1928). Die Ergebnisse lassen sich kurz dahin zusammenfassen, dass isolierte Chromosomen sowohl bei den reinen Arten als auch bei Bastarden der Dinkelgruppe vorkommen, bei den letzteren manchmal bedeutend häufiger als bei den ersteren.

Da diesbezügliche Beobachtungen über die Emmerreihe fehlten, schien es mir wünschenswert, diese Gruppe daraufhin zu prüfen. Nachdem ich meine Studien in Angriff genommen habe, erschienen weitere Arbeiten, die sich mit dieser Frage befassen und auch zum Teil die tetraploiden Weizen berücksichtigen (VAKAR 1930, AASE 1930, THOMPSON und ROBERTSON 1930, DARLINGTON 1931). Die wichtigste ist die Untersuchung von THOMPSON und ROBERTSON, die planmässige statistische Studien der meiotischen Abweichungen bei einer Reihe von Emmerweizen und Bastarden zwischen diesen aus-

(1) Contributions from the Laboratory of Genetics, Biological Institute, Kyoto Imperial University. No. 54.

geführt haben. Sie fanden auch hier mit wenigen Ausnahmen innerhalb enger Grenzen schwankende Zahlen von Univalenten; nur drei Verbindungen, *durum*  $\times$  *dicoccum*, *dicoccum*  $\times$  Khapli und *durum*  $\times$  Khapli, wiesen höhere Frequenzen der Univalenten auf (im letzteren Fall ca. 27%).

Trotzdem das von den kanadischen Autoren bearbeitete Material sehr umfangreich war und ihre statistischen Daten auf grossen Zahlen basieren, schien es aus folgenden Gründen lohnenswert, meine Studien an den Emmerweizen fortzusetzen. Alle bisherigen Untersuchungen, die von THOMPSON und ROBERTSON nicht ausgenommen, gehen nicht über die karyologischen Befunde hinaus und berühren die sehr wichtige Frage der Fertilitätsverhältnisse gar nicht. Auch fiel es auf, dass die letzteren Forscher trotz der sehr hohen Zahlen der geprüften Pollenmutterzellen nie Komplexe gefunden haben. Die Zuverlässigkeit dieses Befundes erschien von vornherein sehr fraglich angesichts der von KIHARA und NISHIYAMA (1928) festgestellten intergenomatischen Beziehungen zwischen den Genomen A und B. Tatsächlich haben schon meine ersten Voruntersuchungen ergeben, dass Tetravalente bei den Bastarden zwischen verschiedenen Emmern gar nicht selten sind<sup>(1)</sup>.

Angesichts dessen habe ich zahlreiche Emmer  $\times$  Emmer-Verbindungen, die immer in beiden Richtungen ausgeführt waren, und auch die Elterarten mit grosser Sorgfalt karyo-statistisch untersucht und die bis jetzt fehlenden Fertilitätsuntersuchungen ausgeführt. Ueber die Ergebnisse dieser Studien wird im folgenden berichtet.

## II. Material und Methoden

Die von mir zu Kreuzungen herangezogenen Arten bzw. Varietäten sind folgende:

<i>Triticum polonicum</i> L. var. <i>vestitum</i> KÖRN.	(2n=28)
<i>T. dicoccum</i> SCHÜBL. var. <i>liguliforme</i> KÖRN.	(2n=28)
<i>T. durum</i> L. var. <i>Reichenbachii</i> KÖRN.	(2n=28)
<i>T. dicoccoides</i> KÖRN. var. <i>Kotschyanum</i> PERC.	(2n=28)
<i>T. turgidum</i> L. var. <i>nigrobarbatum</i> KÖRN.	(2n=28)
<i>T. persicum</i> VAV. var. <i>fuliginosum</i> ZHUK.	(2n=28)
<i>T. persicum</i> VAV. var. <i>stramineum</i> ZHUK.	(2n=28)

(1) Auch AASE (1930) und DARLINGTON (1931) erwähnen, dass sie bei entsprechenden Verbindungen Tetravalente beobachtet haben.

Diese 7 Sippen konnten zu 21 verschiedenen Verbindungen kombiniert werden. Da jede Kreuzung sowohl in der einen als auch in der anderen Richtung ausgeführt wurde, waren im ganzen 42 Verbindungen möglich. Von diesen sind 12 in 1930 und 34 in 1931 untersucht worden, daneben gleichzeitig die jeweiligen Eltern.

Das P.M.Z.-Material wurde in der Regel von mehreren im Versuchsfeld gezogenen Pflanzen entnommen. Die Fixierung erfolgte nach KIHARA's Methode (1924), worauf das Material in Paraffin eingebettet und 14–16  $\mu$  dick geschnitten wurde. Gefärbt wurde mit Heidenhain oder Gentianaviolett (nach NEWTON).

In 1930 wurde der statistischen Untersuchung die Anzahl der P.M.Z., in denen Univalente, Tri- oder Tetrapartite beobachtet wurden, zugrunde gelegt, während Zellen, die keine dieser Unregelmässigkeiten aufwiesen, als normal gerechnet wurden. Im folgenden Jahre aber wurden nur solche Zellen berücksichtigt, in deren metaphasischen Platten sämtliche Elemente feststellbar waren.

### III. Karyologische Untersuchungen bei reinen Arten und bei den $F_1$ -Bastarden

#### 1. Auftreten von isolierten Chromosomen

Bei den reinen Arten bilden in der I. Metaphase 14 zum grössten Teil ringförmige Gemini eine regelmässige Aequatorialplatte. Nur ausnahmsweise findet man ausserhalb dieser ungepaarte Chromosomen (Abb. 1a, b). In 1930 konnten P.M.Z. mit einem<sup>(1)</sup> oder zwei Univalenten bei *T. polonicum*, *dicoccum* und *durum* gefunden werden, in 1931 solche mit zwei Univalenten bei *T. dicoccum*, *durum* und *persicum* var. *fuliginosum* (Tab. 1 und 2). Am häufigsten traten sie in beiden Jahrgängen bei *T. durum* auf, nämlich 4.2% in 1930 und 2.5% in 1931. Bei *T. dicoccum* war kein bedeutender Unterschied zwischen den beiden Jahrgängen zu bemerken (1.0% bzw. 1.7%). Bei *T. polonicum* wurde nur in 1931 hier und da Ausfall der Paarung beobachtet, während bei *T. turgidum* weder im ersten noch im folgenden Jahre Univalente gefunden werden konnten (Tab. 1 und 2). Es kommen also bei reinen Arten nur selten Univalente vor; die höchste beobachtete Zahl der P.M.Z. mit solchen betrug 5 unter 120 P.M.Z. (4.2%) bei *T. durum*.

(1) Ein Univalentes wird in solchen Fällen angegeben, in denen der andere Partner nicht aufzufinden war.

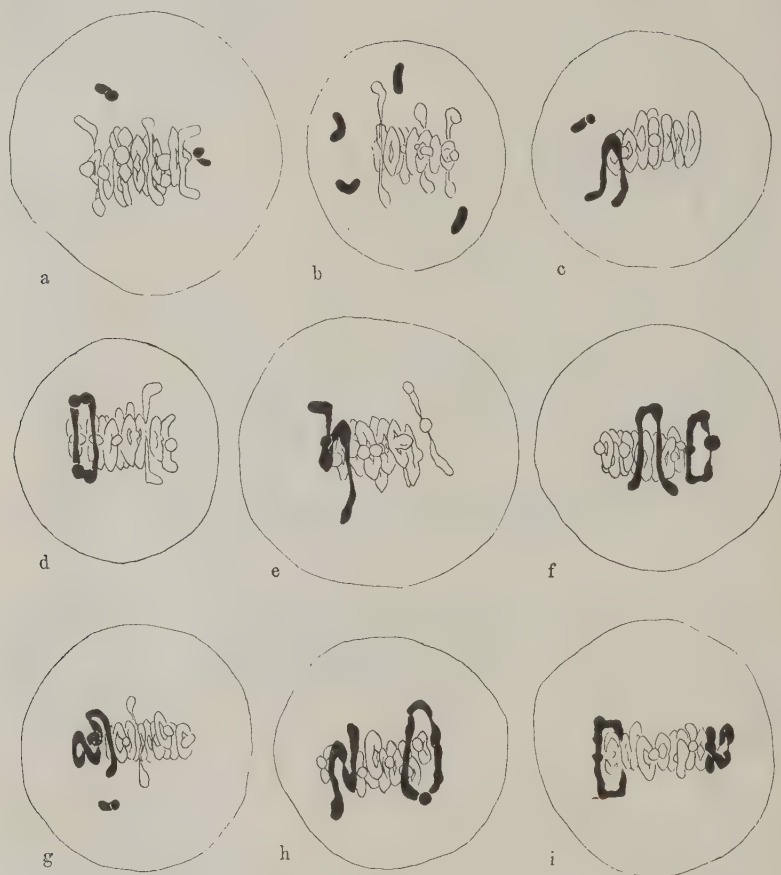


Abb. 1a-i. I. Metaphase P.M.Z. in Äquatorialplatten mit Univalenten und Komplexen in Seitenansicht. Vergr. ca. 1800-fach. a *T. polonicum* × *dicoccoides*;  $13_{II} + 2_{I}$ . b *T. dicoccoides* × *durum*;  $12_{II} + 4_{I}$ . c *T. durum* × *dicoccum*;  $1_{III} + 13_{II} + 1_{I}$ . d *T. persicum fuliginosum*; 1 O-förmiges Tetrapartites und  $12_{II}$ . e *T. dicoccoides*; 1 N-förmiges Tetrapartites und  $12_{II}$ . f *T. dicoccoides* × *dicoccum*;  $2_{IV}$  (das eine U-, das andere O-förmig) +  $10_{II}$ . g *T. dicoccum* × *dicoccoides*;  $1_{IV} + 1_{III} + 10_{II} + 1_{I}$ . h *T. durum* × *dicoccum*;  $2_{IV}$  (das eine N-, das andere O-förmig) +  $10_{II}$ . i *T. durum* × *dicoccum*;  $2_{IV}$  (das eine O-, das andere achterförmig) +  $10_{II}$ .

Bei den  $F_1$ -Bastarden variierte die Zahl der P.M.Z. mit Univalenten innerhalb eines bedeutend weiteren Spielraums (Tab. 1 und 2). Auch traten sie in grösserer Anzahl auf; während bei reinen Arten in keinem Falle mehr als zwei pro Zelle gefunden wurden, konnten in  $F_1$  bis zu sechs festgestellt werden<sup>(1)</sup>.

TABELLE 1. Chromosomenverhältnisse bei reinen Arten und Bastarden der Emmerreihe (1930).

Material	Prozentsatz der P.M.Z. mit						Z. d. unters. P.M.Z.
	normalen Kernplatten	1I	2I	1III	1IV	2IV	
<i>T. polonicum</i>	98.7	0.4	0.9				670
<i>T. dicoccum</i>	99.0	0.3	0.7				583
<i>T. durum</i>	95.8		4.2				120
<i>T. turgidum</i>	100.0						120
<i>T. polonicum</i> × <i>durum</i>	98.4		1.1		0.5		189
<i>T. turgidum</i> × <i>polonicum</i>	98.6				1.4		71
<i>T. dicoccum</i> × <i>durum</i>	73.0	0.9			25.2	0.9	341
rez.	69.1		4.4	7.4	17.6	1.5	68
<i>T. dicoccum</i> × <i>dicoccoides</i>	67.8		1.9		30.4	0.9	214
<i>T. dicoccum</i> × <i>turgidum</i>	71.5				28.5		123
rez.	68.7				28.7	2.7	150
<i>T. durum</i> × <i>dicoccoides</i>	85.5	5.8	3.8		3.8		52
<i>T. durum</i> × <i>turgidum</i>	95.9		4.1				74
rez.	97.6		1.2		1.2		169
<i>T. turgidum</i> × <i>dicoccoides</i>	94.4	0.6	2.7		2.5		323

TABELLE 2. Chromosomenverhältnisse bei reinen Arten und Bastarden der Emmerreihe (1931).

Material	Prozentsatz der P.M.Z. mit						Z. d. unters. P.M.Z.	% d. P.M.Z. mit Unival. nach THOMPS. u. ROB.
	14II	13II + 2I	12II + 4I	1III + 12II + 1I	1IV + 12II	2IV + 10II		
<i>T. polonicum</i>	100.0						88	1.0
<i>T. dicoccum</i>	98.3	1.7					58	2.3
<i>T. durum</i>	97.5	2.5					162	0.8
<i>T. dicoccoides</i>	98.4				1.6		63	3.4
<i>T. turgidum</i>	100.0						271	1.3

(1) Da eine vollständige Analyse der Äquatorialplatten in den betreffenden P.M.Z. nicht möglich war, sind sie in Tab. 2 nicht berücksichtigt worden.



TABELLE 2 (Fortsetzung)

Material	Prozentsatz der P.M.Z. mit						Z. d. unters. P.M.Z.	% d. P.M.Z. mit Unival. nach THOMPS. u. ROB.
	14II	13II+2I	12II+4I	11II+12II+1I	1IV+12II	2IV+10II		
<i>T. persicum fuliginosum</i>	98.4	1.1			0.5		182	0.5
<i>T. polonicum</i> × <i>dicoccum</i>	81.0				19.0		58	
rez.	70.2				28.2	1.6	124	8.8
<i>T. polonicum</i> × <i>durum</i>	97.8	1.1	1.1				93	
rez.	100.0						36	7.8
<i>T. polonicum</i> × <i>dicoccoides</i>	87.1	9.4	0.7		2.9		139	
rez.	84.7	11.5	3.8				26	
<i>T. polonicum</i> × <i>turgidum</i>	100.0						137	
rez.	100.0						186	8.8
<i>T. polonicum</i> × <i>persicum fuliginosum</i>	95.6	4.4					45	
rez.	93.3	3.3			3.3		120	
<i>T. polonicum</i> × <i>persicum stramineum</i>	91.7	4.4		0.5	3.3		180	
rez.	92.3	1.3			6.4		78	
<i>T. dicoccum</i> × <i>durum</i>	69.3				30.7	(1)	75	
rez.	77.5				20.3	2.2	182	21.5
<i>T. dicoccum</i> × <i>dicoccoides</i>	63.2	1.7			35.1		57	4.5
<i>T. dicoccum</i> × <i>turgidum</i>	71.5				28.5		123	
rez.	70.7	1.7			27.6		58	5.5
<i>T. persicum fuliginosum</i> × <i>dicoccum</i>	67.0				30.9	2.0	97	
<i>T. persicum stramineum</i> × <i>dicoccum</i>	77.8				22.2		18	
<i>T. durum</i> × <i>dicoccoides</i>	86.6	9.0	0.7		3.7		134	8.0
rez.	83.1	11.2	1.4		4.2		71	
<i>T. durum</i> × <i>turgidum</i>	87.4	2.2			10.4	(1)	135	
rez.	100.0						82	
<i>T. durum</i> × <i>persicum fuliginosum</i>	93.3				6.7		15	1.8
<i>T. persicum stramineum</i> × <i>durum</i>	97.1	1.9			1.0		210	
<i>T. dicoccoides</i> × <i>turgidum</i>	96.1	3.3					150	
rez.	90.4	4.2			5.4		261	6.7
<i>T. dicoccoides</i> × <i>persicum fuliginosum</i>	90.9	2.9			5.8	0.4	480	
rez.	90.6	1.3			8.1		160	
<i>T. turgidum</i> × <i>persicum fuliginosum</i>	96.6				3.4		58	2.7
rez.	93.4				1.6		191	
<i>T. persicum stramineum</i> × <i>turgidum</i>	98.7				1.3		226	
<i>T. persicum fuliginosum</i> × <i>stramineum</i>	97.4	2.6					117	
rez.	97.0	3.0					168	
<i>T. dicoccum</i> "Vernal" × "Khapli"								24.5
<i>T. durum</i> × <i>dicoccum</i> "Khapli"								26.9

(1) In Platten, die näher nicht analysierten waren, habe ich sicher mehr als einmal 2IV gesehen.

Wie aus Tab. 1 und 2 zu entnehmen ist, traten P.M.Z. mit Univalenten am häufigsten bei *T. dicoccoides*  $\times$  *polonicum* (15.3%) und bei *T. dicoccoides*  $\times$  *durum* (12.6%) auf. Auch die Gegenkreuzungen wiesen hohe Zahlen auf (10.1% bzw. 9.7%)<sup>ω</sup>. Bei den übrigen F<sub>1</sub>-Bastarden übersteigt die Anzahl der P.M.Z. mit Univalenten nicht 4.5%. Es ist bemerkenswert, dass sie in allen diesen Fällen sehr variabel ist. Nicht nur, dass derartige P.M.Z. in manchen Kreuzungen (z.B. *T. polonicum*  $\times$  *durum*, *dicoccum*  $\times$  *turgidum* und *durum*  $\times$  *turgidum*) nur in einer Kreuzungsrichtung gefunden wurden, in der anderen nicht, aber auch bei ein und demselben Bastard kommen des öfteren stark abweichende Zahlen vor, je nach dem Fixierungsdatum (Tab. 3).

TABELLE 3. Häufigkeit der Pollenmutterzellen mit 2 Univalenten.

Material	Fixierungsdatum	Prozentsatz d. P.M.Z. mit		Z. d. unters. P.M.Z.
		14II	13II+2I	
<i>T. dicoccoides</i> $\times$ <i>turgidum</i>	17 Mai 1931	90.0	10.0	50
	19 Mai 1931	100.0	0.0	100
<i>T. persicum stramineum</i>	3 Juni 1931	97.4	2.6	116
$\times$ <i>fuliginosum</i>	8 Juni 1931	100.0	0.0	52

Mehr als 2 Univalente wurden in der Regel (mit Ausnahme von *T. polonicum*  $\times$  *durum*) bei solchen Verbindungen festgestellt, die eine relativ hohe Frequenz der Zellen mit 2 Univalenten zeigten. Wenn angenommen wird, dass zufälliger Ausfall der Paarung die Ursache des Auftretens der isolierten Chromosomen ist, dann kann die theoretische Anzahl der Zellen mit 4 Univalenten durch Quadrierung der gefundenen P.M.Z.-Zahl mit 2 Univalenten errechnet werden. Die Zahlen sind aus Tab. 4 zu ersehen.

TABELLE 4. Gefundene und theoretische Häufigkeit der Pollenmutterzellen mit 4 Univalenten.

Material	2 Unival.	Prozentsatz d. P.M.Z. mit 4 Unival.		Z. d. unters. P.M.Z.
		gefunden	erwartet	
<i>T. polonicum</i> $\times$ <i>dicoccoides</i>	9.4	0.7	0.88	139
<i>T. durum</i> $\times$ <i>dicoccoides</i>	9.0	0.7	0.81	134
<i>T. dicoccoides</i> $\times$ <i>durum</i>	11.2	1.4	1.25	71
<i>T. polonicum</i> $\times$ <i>durum</i>	1.1	1.1	0.01	93
<i>T. dicoccoides</i> $\times$ <i>polonicum</i>	11.5	3.8	1.32	26

(1) Es ist von Interesse, dass die Verbindung *durum*  $\times$  *dicoccoides* auch im J. 1930 die höchste Frequenz I. Metaphasen mit Unregelmäßigkeiten aufwies, nämlich 9.6% (die reziproke Kreuzung stand dem Verf. in diesem Jahre leider nicht zur Verfügung).

In den ersten drei Fällen der Tab. 4 stimmen die gefundenen Zahlen mit den erwarteten gut überein. In den letzten zwei sind aber die gefundenen Zahlen bedeutend höher. Die Ursache hierfür ist vielleicht darin zu suchen, dass gerade in diesen zwei Fällen die P.M.Z. der untersuchten Antherenfächer zum grössten Teil in Anaphase standen<sup>(1)</sup>.

2. Auftreten von Chromosomenverbänden bei reinen Arten und bei den  $F_1$ -Bastarden

Viergliedrige Chromosomenkomplexe, die vorläufig als Tetrapartite bezeichnet werden sollen (vgl. Diskussion, S. 319–20), treten, wenn auch sehr selten, bei reinen Arten der tetraploiden Weizenreihe auf. Sie wurden, wie aus Tab. 2 zu ersehen ist, bei *T. persicum fuliginosum*, *T. dicoccoides* und *T. dicoccum* festgestellt (Abb. 1 d und e). Soweit bis jetzt beobachtet, ist die Bindungsweise der sie konstituierenden Chromosomen akrosyndetisch.

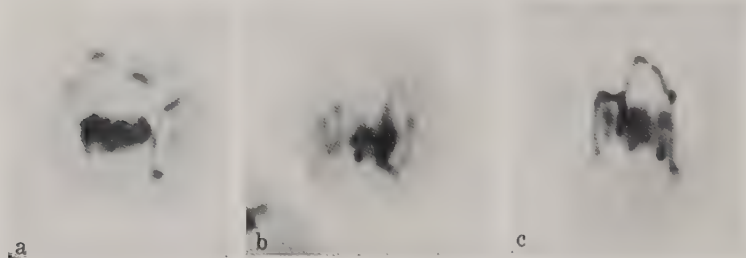


Abb. 2a-c. Mikrophographien. I. Metaphase in Seitenansicht. Vergr. ca. 1500-fach. a *T. dicoccoides* × *durum*; 3 von 4 Univalenten im Gesichtsfeld. b *T. durum* × *dicoccum*; 2IV. Dieselbe P.M.Z. wie die in Abb. 1h. c *T. durum* × *dicoccum*; 1VIII.

Bei den  $F_1$ -Bastarden der gleichen Weizenreihe treten Tetrapartite bei weitem häufiger auf (Tab. 1 und 2, Abb. 1 f–i, 2b). Den höchsten Prozentsatz der P.M.Z. mit Tetrapartiten weisen die Verbindungen mit *T. dicoccum* auf (in jedem Falle mehr als 19%). Den nächsten Platz nimmt der Bastard *T. durum* × *turgidum* ein (10.4%), auf den mehrere Verbindungen mit *T. persicum* folgen (*T. persicum fuliginosum* × *dicoccoides* mit 8.1%, *T. durum* × *persicum fuliginosum* mit 6.7% und *T. persicum stramineum* × *polonicum* mit 6.4%).

(1) HOLLINGSHEAD (1932) berichtet, dass bei einem intraspezifischen Bastard bei *T. vulgare* "higher univalent frequency occurred in metaphase cells from anthers in which most of the cells were well past metaphase."

Auch hier begegnen wir einer weitgehenden Variabilität in der Anzahl der P.M.Z. mit Tetrapartiten. Es stellten sich nicht nur reziproke Unterschiede in dieser Beziehung heraus, sondern auch starke Schwankungen bei ein und derselben Verbindung, im Material, das an verschiedenen Tagen fixiert wurde. Aus Tab. 5 ist z.B. zu ersehen, dass bei *T. polonicum*  $\times$  *dicoccoides*, *T. persicum fuliginosum*  $\times$  *polonicum*, *T. durum*  $\times$  *turgidum*, *T. persicum stramineum*  $\times$  *durum* und *T. turgidum*  $\times$  *dicoccoides* wohl Tetrapartite auftreten, bei den entsprechenden reziproken Bastarden aber, die an gleichem Tage fixiert wurden, fehlen. Die gleiche Tabelle zeigt, dass die Verbindungen *T. durum*  $\times$  *turgidum* und *T. turgidum*  $\times$  *dicoccoides*, an verschiedenen Tagen fixiert, bedeutende Differenzen in der Anzahl der Zellen mit Tetrapartiten aufweisen, im ersteren Falle ca. 19%. Es ist bemerkenswert, dass mit der Abnahme bzw. bei Abwesenheit derartiger P.M.Z. die Anzahl solcher mit Univalenten zunimmt, die Verbindungen *T. dicoccum*  $\times$  *dicoccoides* und *T. dicoccoides*  $\times$  *durum* ausgenommen.

TABELLE 5. Häufigkeit der Pollenmutterzellen mit 1 Tetrapartiten

Material	Fixierungsdatum	Prozentsatz d. P.M.Z. mit 1 Tetrapart.	Z. d. unters. P.M.Z.
<i>T. polonicum</i> $\times$ <i>dicoccoides</i> rez.	17 Mai 1931	2.9	139
	17 Mai 1931	0.0	26
<i>T. polonicum</i> $\times$ <i>persicum fulig.</i> rez.	23 Mai 1931	0.0	45
	25 Mai 1931	3.3	120
<i>T. durum</i> $\times$ <i>turgidum</i> " rez.	18 Mai 1931	0.0	61
	2 Juni 1931	18.9	74
	2 Juni 1931	0.0	82
<i>T. persicum stram.</i> $\times$ <i>durum</i> "	25 Mai 1931	1.4	150
	21 Mai 1931	0.0	60
<i>T. dicoccoides</i> $\times$ <i>turgidum</i> " rez. " rez. " rez.	17 Mai 1931	0.0	50
	19 Mai 1931	0.0	100
	18 Mai 1931	8.8	80
	2 Juni 1931	0.0	47
	2 Juni 1931	5.2	134

Die Verbindungen zwischen zwei sich sehr nahe stehenden Varietäten von *T. persicum* (*fuliginosum*  $\times$  *stramineum*) zeigten weder in der einen noch in der anderen Kreuzungsrichtung Tetrapartite.

Tripartite, von Univalenten begleitet (Abb. 1c), sowie aus mehr als 4 Chromosomen bestehende Verbände wurden ab und zu beobachtet (Abb. 1g und 2c).

### 3. Morphologie der Chromosomenverbände

In Polansichten konnten die Tetrapartiten nur in einzelnen Fällen leicht unterschieden werden (Abb. 3). Im allgemeinen waren die Seitenansichten viel günstiger für die Beobachtung der Komplexe, vor allem bei zickzackförmiger Anordnung der Glieder. Abb. 1 d, e, f, h und i bringen eine Reihe P.M.Z. mit Tetrapartiten. Wie mannigfaltig deren Morphologie sein kann, zeigen Abb. 4 k-w.

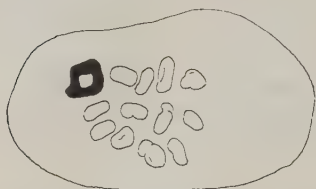


Abb. 3. *T. durum* × *dicocoum*. I. Metaphase in Polansicht. 1IV+12II. Vergr. ca. 1800-fach.

AASE (1930) berichtet, dass sie bei Weizenbastarden offene (auch asymmetrische) U-förmige oder geschlossenen ringförmige Tetrapartite, deren Glieder akrosyndetisch verbunden waren, gefunden hat. Auch in den Abbildungen anderer Autoren, die derartige Verbände bei inter- oder intraserialen Weizenkreuzungen angeben (KIHARA und NISHIYAMA 1928 und 1930,

WAKAKUWA 1929 und THOMPSON und ROBERTSON 1930 kann man vollständig oder fast vollständig terminalisierte Bindungsweise sehen. Da aber die Terminalisierung der Chiasmata bei *Triticum* im allgemeinen unvollständig ist (DARLINGTON 1931), waren mannigfaltige Konfigurationstypen der Tetrapartiten zu erwarten und sind auch gefunden worden<sup>(1)</sup>. So waren z.B. die aneinanderstossenden Chromosomen manchmal an einer oder auch an zwei Stellen des Verbandes durch zwei Chiasmata verbunden (Abb. 4 m, o, p und v). Da O-förmige Tetrapartite eine geschlossene Modifikation der U-förmigen sind, war auch eine geschlossene zickzackförmige Modifikation der N-förmigen Tetrapartiten zu erwarten. Diese ist in Abb. 4 q und r dargestellt. Ferner wurden achterförmige Figuren gefunden. Eine derartige Anordnung, durch Terminalisierung eines vierfachen Chiasmas entstanden, bringt Abb. 4s. Sie konnte nur bei dem Bastard *T. dicoccoides* × *persicum fuliginosum* festgestellt werden, dessen beide Eltern Tetrapartite mit akrosyndetischer Bindungsweise zeigten. Einen anderen Typus bringt Abb.

(1) DARLINGTON (1931) gibt Tetrapartite bei Weizen an, bringt aber keine Abbildungen.



4w. Hier sehen wir, dass von zwei zwischen dem dritten und vierten Chromosom gebildeten Chiasmata das distale in der Terminalisierung zurückgeblieben ist.

Bei Konfigurationen wie die in Abb. 4 l und u erfolgt wahrscheinlich eine ungleiche Verteilung der Glieder, indem ein Chromosom an einen, die drei übrigen an den anderen Pol gehen.

Da solche Typen wie die in Abb. 4 s und w gebrachten recht selten sind, können wir in der Hauptsache zweierlei Konfigurationen der Tetrapartiten unterscheiden: 1. Ring (bzw. U)- und 2. zickzack (bzw. N)-förmige Konfigurationen. Tabelle 6 orientiert über die Häufigkeit dieser beiden Haupttypen. Auf Grund der in der Literatur vorliegenden Angaben waren die beiden Kategorien ungefähr in gleicher Zahl zu erwarten. Die gefundenen Verhältniszahlen sind aber 70.6% Ringe und 29.4% Zickzacke. Die Verschiebung der Zahlen zugunsten der Ringe erklärt sich daraus, dass die Beobachtungen an Seitenansichten gemacht wurden, in denen die Ringe viel leichter feststellbar sind als die Zickzacke.

TABELLE 6. Häufigkeit der ring- und zickzackförmigen Konfigurationen der Tetrapartiten.

Material	Ring (bzw. U)	Zickzack (bzw. N)	Summe	Z. d. unters. P.M.Z.
<i>T. dicoccoides</i>	—	1	1	63
<i>T. persicum fuliginosum</i>	2	—	2	182
<i>T. polonicum</i> × <i>dicoccum</i>	9	2	11	58
rez.	34	3	37	124
<i>T. polonicum</i> × <i>dicoccoides</i>	2	2	4	139
<i>T. persicum fulig.</i> × <i>polonicum</i>	2	2	4	120
<i>T. polonicum</i> × <i>persicum stram.</i>	3	3	6	180
rez.	4	1	5	78
<i>T. dicoccum</i> × <i>durum</i>	18	5	23	75
rez.	30	15	45	182
<i>T. dicoccum</i> × <i>dicoccoides</i>	16	4	20	57
<i>T. dicoccum</i> × <i>turgidum</i>	27	8	35	123
rez.	14	2	16	58
<i>T. persicum fulig.</i> × <i>dicoccum</i>	22	12	34	97
<i>T. persicum stram.</i> × <i>dicoccum</i>	3	1	4	18
<i>T. durum</i> × <i>dicoccoides</i>	5	—	5	134
rez.	—	3	3	71
<i>T. durum</i> × <i>turgidum</i>	9	5	14	135
<i>T. durum</i> × <i>persicum fulig.</i>	—	1	1	15
<i>T. persicum stram.</i> × <i>durum</i>	2	—	2	210
<i>T. turgidum</i> × <i>dicoccoides</i>	7	7	14	261
<i>T. dicoccoides</i> × <i>persicum fulig.</i>	17	15	32	480
<i>T. turgidum</i> × <i>persicum fulig.</i>	1	1	2	58
rez.	1	2	3	191
<i>T. persicum stram.</i> × <i>turgidum</i>	2	1	3	226
Summe	230 (70.6%)	96 (29.4%)	326 (100.0%)	3335

Abb. 2c bringt ein Beispiel höherchromosomiger Komplexe; wahrscheinlich sind hier 8 Chromosomen beteiligt. Trotz der recht komplizierten Anordnung ist die Terminalisierung vollständig.

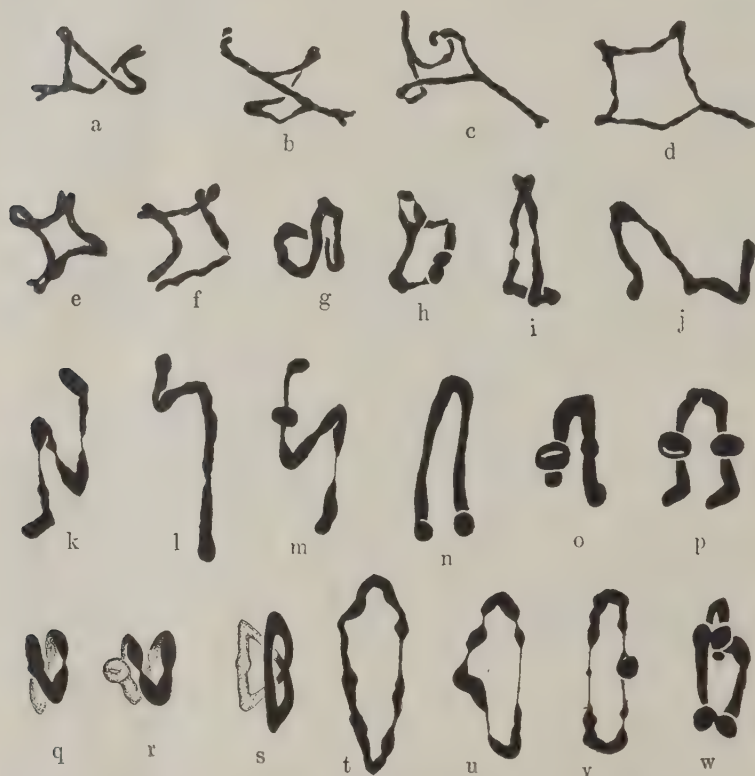


Abb. 4a-w. Verschiedene Tetrapartitentypen aus verschiedenen meiotischen Stadien. Vergr. ca. 2500-fach. a-d Späteres Diplotän. e-j Diakinese. k-w Metaphase. (a-d, f-i und n-p *T. dicoccum* × *polonicum*; e, q, r, u und w *T. durum* × *dicoccum*; j *T. dicoccum* × *durum*; k, l, t und v *T. dicoccum* × *dicoccoides*; m *T. turgidum* × *dicoccoides*.)

Tripartite sind meist V-förmig und weisen stets vollständig terminalisierte Chiasmata auf. Hier und da nehmen sie asymmetrische Gestalt an, wie in Abb. 1g, wo ein Univalentes an ein Bivalentes angehängt erscheint. Höchst wahrscheinlich handelt es

sich hier um dieselben Chromosomen, die sonst an der Bildung der Tetrapartiten teilnehmen, deren Glieder gelegentlich als  $1_{III} + 1_I$  auftreten können.

Die Untersuchung der Prophasen bietet bei *Triticum* beträchtliche Schwierigkeiten. Trotzdem konnten in späterem Diplonema Tetrapartite einwandfrei festgestellt werden (Abb. 4 a–d und 5 a). Die Terminalisierung der Chiasmata ist oft in diesem Stadium merklich weniger vorgeschritten als in späteren Stadien. Manchmal sind die Chromosomen miteinander subterminal verbunden und die Enden erscheinen frei (Abb. 4a). Nicht selten konnte Konjugation auf längeren Strecken beobachtet werden (Abb. 4 b–d).

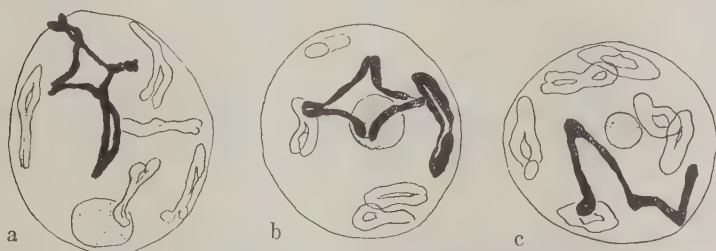


Abb. 5a–c. Diplotän- und Diakinese-Kerne mit Tetrapartiten. Vergr. ca. 2500-fach. a *T. dicoccum* × *polonicum*; 1 Tetrapartites. b *T. durum* × *dicoccum*; 2 geschlossene Tetrapartite. c *T. dicoccum* × *durum*; 1 N-förmiges Tetrapartites.

Abb. 4 e–j und 5 b–c zeigen Tetrapartite in Diakinese. Abb. 5c bringt einen N-förmigen Komplex. Auch sieht man oft an einer oder an zwei Stellen eines Verbandes eine lockere Verbindung oder auch gar keinen Zusammenhang zwischen zwei benachbarten Chromosomen (Abb. 4 f und i). In solchen Fällen entstehen U-förmige Komplexe oder auch ein Tripartites neben einem Univalenten. Abb. 4h entspricht dem Tetrapartiten in Metaphase aus Abb. 4w.

Zur leichteren Uebersicht sind in Abb. 6 die Chromosomen aus einzelnen P.M.Z. in Diplonema, Diakinese und Metaphase in horizontalen Längsreihen angeordnet. In den beiden ersten Stadien konnte die Zahl der Chiasmata nicht sicher festgestellt werden. Es unterliegt aber keinem Zweifel, dass sie sich zwischen Diplonema und Metaphase verringert, womit eine Konzentrierung der Chiasmata in den distalen Enden der Chromosomen Hand in Hand geht.

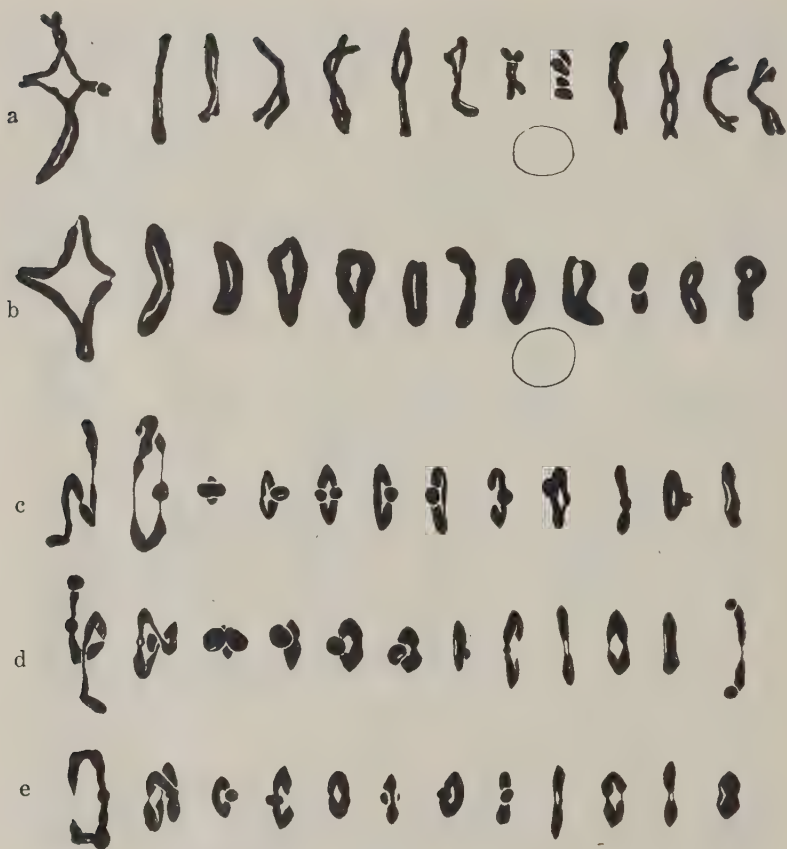


Abb. 6a-e. Meiotische Chromosomen aus verschiedenen Stadien, einzeln gezeichnet. a *T. dicoccum* × *polonicum*; derselbe Diplotänkern wie in Abb. 5a. Vergr. ca. 2400-fach. b *T. durum* × *dicoccum*; derselbe Diakinesekern wie in Abb. 5b. Vergr. ca. 2400-fach. c-e *T. durum* × *dicoccum*; Chromosomen aus 3 metaphasischen Platten mit  $2_{IV}+10_{II}$ . Vergr. ca. 1800-fach.

#### 4. Fertilitätsverhältnisse bei reinen Arten und den $F_1$ -Bastarden

Angesichts der Komplexbildung und des Univalentenvorkommens erschien eine nähere Untersuchung über die Fertilität der Elterarten und der Bastarde von grösserem Interesse. Sie wurde folgendermassen ausgeführt. Als Material dienten nur isolierte

TABELLE 7. Fertilitätsverhältnisse bei reinen Arten und Bastarden der Emmerreihe.

Material	Jahrg.	Zahl d. Ähren	Durchschn. Zahl d. Ährchen pro Ähre	Durchschn. Zahl d. Körner pro Ähre		Zahl d. sterilen untersten Ährchen	Fertilitäts-% (1.-2. Bl.)
				1.-2. Blütchen	3. Blütchen		
<i>T. polonicum</i>	1931	3	28.67	40.33	6.33	4-6	70.5
<i>T. dicoccum</i>	1931	3	27.00	34.00		1	62.9
<i>T. durum</i>	1931	2	21.50	41.00	12.00	0-2	95.3
<i>T. dicoccoides</i>	1931	1	16.00	24.00		2	75.0
<i>T. turgidum</i>	1931	2	31.00	58.00	18.00	1	93.5
<i>T. persicum fuliginosum</i>	1931	6	20.50	32.00	0.83	1	78.0
<i>T. persicum stramineum</i>	1931	7	21.57	33.57	3.14	1-2	77.8
<i>T. polonicum</i> × <i>dicoccum</i> rez.	1930	20	30.95	48.65	3.00	1-2	78.6
	1930	16	29.31	47.31	1.33	2-3	80.7
<i>T. polonicum</i> × <i>durum</i> rez.	1930	20	26.90	49.75	16.50 <sup>(1)</sup>	1	92.5
	1930	20	26.55	49.05	15.00 <sup>(1)</sup>	1-2	92.4
<i>T. polonicum</i> × <i>dicoccoides</i> rez.	1930	21	21.75	33.89	0.50	1-2	77.9
	1930	22	22.41	36.50	2.33	1-2	81.4
<i>T. polonicum</i> × <i>turgidum</i> rez.	1930	20	33.30	62.00	18.50	1-3	93.1
	1930	22	32.05	58.36	13.50	1-5	91.0
<i>T. polonicum</i> × <i>persicum fuliginosum</i> rez.	1931	11	26.27	42.56	0.36	2-4	81.0
	1931	11	27.36	43.45	0.73	2-3	79.4
<i>T. polonicum</i> × <i>persicum stramineum</i> rez.	1931	6	26.00	45.83	1.33	1-4	88.1
	1931	10	26.30	43.30	0.30	2-4	82.3
<i>T. dicoccum</i> × <i>durum</i> rez.	1930	20	24.90	44.75	?	?	89.9
	1930	21	26.24	46.33	4.00	?	88.5
<i>T. dicoccum</i> × <i>dicoccoides</i> rez.	1930	25	20.68	27.28		0-2	66.0
	1930	21	21.24	32.00		0-3	75.3
<i>T. dicoccum</i> × <i>turgidum</i> rez.	1930	20	33.60	60.75	5.00	1	90.4
	1930	20	32.85	58.20	8.00	1	88.6
<i>T. dicoccum</i> × <i>persicum fuliginosum</i> rez.	1931	10	24.40	36.70	1.00	1-2	75.2
	1931	10	25.10	40.50	0.40	1	80.7
<i>T. dicoccum</i> × <i>persicum stramineum</i> rez.	1931	12	23.60	41.00	1.08	0	86.9
	1931	10	24.40	40.40	0.70	0-1	82.8
<i>T. durum</i> × <i>dicoccoides</i> rez.	1930	23	18.30	24.96		1-2	72.1
	1930	25	18.08	22.04		1-2	61.0
<i>T. durum</i> × <i>turgidum</i> rez.	1930	20	27.10	52.35	guter Ansatz <sup>(2)</sup>	?	96.6
	1930	20	28.10	53.15	18.00	1-2	94.6

(1) bzw. 4. Blütchen.

(2) nicht gezählt.



TABELLE 7 (Fortsetzung)

Material	Jahrg.	Zahl d. Aehren	Durchschn. Zahl d. Aehren pro Aehre	Durchschn. Zahl d. Körner pro Aehre		Zahl d. sterilen untersten Aehren	Fertilitäts- % (1.-2. Bl.)
				1.-2. Blütchen	3. Blütchen		
<i>T. durum</i> × <i>persicum</i> <i>fuliginosum</i> rez.	1931	10	21.10	35.90	4.40	1-2	85.1
	1931	10	22.20	38.90	3.60	1-2	87.6
<i>T. durum</i> × <i>persicum</i> <i>stramineum</i> rez.	1931	10	21.20	33.70	4.20	1-3	79.5
	1931	10	20.60	34.00	4.90	1-3	82.5
<i>T. dicoccoides</i> × <i>turgidum</i> rez.	1930	20	22.70	39.15		0-(3)	86.2
	1930	20	22.60	39.50	6.00	0-(3)	87.4
<i>T. dicoccoides</i> × <i>persicum</i> <i>fuliginosum</i> rez.	1931	4	17.50	14.00		2-3	40.0
	1931	2	15.00	7.50		2-3	25.0
<i>T. turgidum</i> × <i>persicum</i> <i>fuliginosum</i> rez.	1931	10	27.80	49.50	1.90	1-3	89.0
	1931	10	27.00	48.60	2.00	1-3	90.0
<i>T. turgidum</i> × <i>persicum</i> <i>stramineum</i> rez.	1931	10	28.00	46.60	1.00	1-2	83.2
	1931	10	26.40	38.10	3.30	1-3	72.2
<i>T. persicum</i> <i>fuliginosum</i> × <i>stramineum</i> rez.	1931	10	23.40	42.40	3.70	1-2	90.6
	1931	10	21.80	36.60	3.20	1-2	83.9

Aehren. Es wurde der Ansatz in den zwei ersten und im dritten Blütchen jedes Aehrchens getrennt festgestellt. Der prozentualen Bestimmung des Körneransatzes liegen die im ersten und zweiten Blütchen gefundenen Körner zugrunde. Tabelle 7 orientiert über die gefundenen Fertilitätsgrade. Aus dieser ist zu ersehen, dass die reinen Arten bedeutende Unterschiede in der Fertilität aufweisen. Am wenigsten fertil ist *T. dicoccum* (ca. 63%), das sich für unser Klima nicht gut eignet und ausserdem auch durch den besonderen Aehrenaufbau zur Sterilität neigt. Die Spindelglieder im oberen Teil der Aehre sind nämlich ausserordentlich kurz, wodurch eine charakteristische Krümmung dieses Aehrenteils zustande kommt. Zwei bis drei der obersten Aehrchen sind gänzlich steril und die darauffolgenden unteren drei bis acht produzieren in der Regel nur je ein Korn.

Den nächsten Platz nimmt *T. polonicum* mit ca. 70% Ansatz ein. Die niedrige Fertilität in diesem Falle hängt, wenigstens zum Teil, sicher damit zusammen, dass 4-6 unterste Aehrchen in der

Aehre stets steril sind. Die höchste Fertilität zeigen *T. turgidum* und *durum* mit ca. 95% Ansatz.

Wenn wir die einzelnen Verbindungen der Tab. 7 ins Auge fassen, dann sehen wir, dass der Fertilitätsgrad in den meisten Fällen eine deutliche Abhängigkeit von demjenigen der Elterarten zeigt und sich als intermediär erweist. So haben die Verbindungen mit *T. turgidum* und *durum* die höchsten Fertilitätsgrade, wenn das andere Elter nicht gerade zu den am wenigsten fertilen gehört.

Auffallend wenig fertil im Verhältnis mit den Eltern erscheint nur die Verbindung *T. dicoccoides*  $\times$  *persicum fuliginosum* mit 40% Ansatz, wenn *dicoccoides*, und mit 25% Ansatz, wenn *persicum fuliginosum* Mutter war. Doch kann diesem Resultat keine grössere Bedeutung zugeschrieben werden, da die isolierten Aehren dieser Verbindung infolge ausgesprochen kriechenden Wuchses unter Regenwetter stark gelitten hatten (vgl. LILIENFELD und KIHARA 1934).

Kurz zusammenfassend kann man wohl sagen, dass bei den untersuchten Bastarden der Emmerreihe Bastardsterilität nicht in Frage kommt.

#### IV. Diskussion und Ergebnisse

1. Es wurden 20 verschiedene Verbindungen zwischen 7 Emmerarten hergestellt. Sämtliche Bastarde und sechs reine Arten wurden auf das Vorkommen ungepaarter Chromosomen in I. Metaphase mit folgendem Resultat untersucht.

Bei reinen Arten findet man ab und zu P.M.Z. mit 1–2 Univalenten (Tab. 1–2). Ihr seltenes Vorkommen (höchstens ca. 4%) weist darauf hin, dass die Isolierung der betreffenden Chromosomen auf zufälligen Ausfall der Paarung zwischen Homologen zurückzuführen ist.

Bei den meisten der 34 untersuchten  $F_1$ -Bastarde (die reziproken Verbindungen mitgerechnet) wurden auch P.M.Z. mit 1–2 Univalenten in ähnlicher Frequenz wie bei den reinen Arten nachgewiesen. Auch hier dürfte die Ursache des isolierten Auftretens in zufälligem Ausfall der Paarung zu suchen sein.

Nur in 2 Fällen, *T. polonicum*  $\times$  *dicoccoides* und rez. sowie *T. dicoccoides*  $\times$  *durum* und rez., wurden höhere Zahlen derartiger P.M.Z. festgestellt, nämlich 9–11%. Hier muss man wohl annehmen,

dass geringe Differenzen zwischen den Partnern eines Paares vorhanden sind, die das Paarungsvermögen abschwächen.

Es ist bemerkenswert, dass mehr als 2, und zwar 4 Univalente pro Zelle, mit Ausnahme von *T. polonicum*  $\times$  *durum*, gerade bei den beiden Verbindungen mit höchsten Frequenzen von Zellen mit 2<sub>1</sub> vorkommen (*T. dicoccoides*  $\times$  *durum* und *T. polonicum*  $\times$  *dicoccoides*). Die Häufigkeit der beobachteten P.M.Z. mit 4<sub>1</sub> entspricht ganz gut der quadrierten Zahl der P.M.Z. mit 2<sub>1</sub>.

2. Die Frequenz der Zellen mit Univalenten ist in hohem Grade variabel und je nach Jahrgang, Kreuzungsrichtung und Fixierungsdatum verschieden (Tab. 3).

3. Sporadisches Vorkommen von Univalenten bei Verbindungen innerhalb der tetraploiden Weizengruppe erwähnt AASE (1930). Die ausführlichste Untersuchung über diese Erscheinung bei der gleichen Gruppe liegt aber nur von THOMPSON und ROBERTSON vor (1930). Die Resultate stimmen im grossen und ganzen mit den hier mitgeteilten insoweit überein, als auch die kanadischen Autoren bei den meisten der geprüften Verbindungen ähnliche kleine Zahlen von Zellen mit der betreffenden Abweichung gefunden haben. Im einzelnen weichen die Angaben von unseren ab, was bei den reinen Arten und den Verbindungen mit niedriger Anzahl solcher Zellen zu erwarten war. Dass die Zahlen von THOMPSON und ROBERTSON sich durchwegs höher stellen als meine und auch die Verbindungen mit zahlreichsten Abweichungen nicht die gleichen sind wie bei mir, dürfte vor allem auf der verschiedenen Arbeitsweise beruhen. Die von mir gegebenen Werte sind wohl in dieser Beziehung die zuverlässigeren, da meine Untersuchungen sich fast ausschliesslich auf die mittlere I. Metaphase beziehen und zum grössten Teil nur P.M.Z. mit vollkommen analysierbaren Platten berücksichtigen. Von Interesse ist die Angabe der kanadischen Autoren von 21.5% P.M.Z. mit Univalenten bei *T. durum*  $\times$  *dicoccum*, wo ich keine isolierten Chromosomen beobachtet habe. Ferner nennen die beiden Forscher 2 Verbindungen mit einem indischen tetraploiden Weizen Khapli, den sie zu *T. dicoccum* stellen, nämlich *T. dicoccum* Vernal  $\times$  *dicoccum* Khapli und *T. durum*  $\times$  *dicoccum* Khapli mit ca. 24 bzw. 27% P.M.Z. mit Univalenten. Leider fehlt jede Angabe über die Fertilität dieser Verbindungen.

4. Bei den gleichen reinen Arten und F<sub>1</sub>-Bastarden wurden auch Chromosomenverbände, vor allem viergliedrige, studiert. Es

hat sich gezeigt, dass solche Verbände, meist einer, selten 2 pro Zelle, fast bei allen Verbindungen vorkommen. Die Frequenz der Zellen mit viergliedrigen Komplexen variiert von Verbindung zu Verbindung; ihre höchste Anzahl wies *T. dicoccum*  $\times$  *dicoccoides* auf (ca. 35%). Auch die Zahlen der P.M.Z. mit Tetrapartiten sind je nach den äusseren Bedingungen variabel; wenn aber eine Verbindung einmal eine hohe Frequenz derartiger Zellen aufweist, dann ist es meistens mit den beiden Gegenkreuzungen der Fall (Tab. 5). Zur Erklärung der Verbände liegt es am nächsten, anzunehmen, dass zwei Chromosomenpaare aus dem Genom A mit zwei Paaren aus dem Genom B zu je einem vierteiligen Komplex zusammentreten können. Dass wir hier mit richtiger auf Homologie beruhender Chromosomenpaarung zu tun haben, geht aus den Figuren in Diplonema und Diakinese (Abb. 4 a–j und 5) einwandfrei hervor.

Es stehen nun zwei Fragen im Vordergrund der Diskussion:

a. Welcher Art sind die Homologieverhältnisse zwischen den Gliedern der vierteiligen Verbände? und b. Warum werden sie bei den reinen Arten entweder gar nicht oder nur sporadisch gebildet?

Bei der Beantwortung der ersten Frage handelt es sich vor allem darum, ob wir mit partieller oder vollkommener Homologie der betreffenden Chromosomen zu tun haben. Befunde von dreierlei Art können zur Entscheidung herangezogen werden, nämlich 1. Ergebnisse der karyologischen Studien, 2. Resultate der Fertilitätsuntersuchungen bei den  $F_1$ -Bastarden und deren Nachkommenschaft und 3. faktoranalytische Versuche. Vorläufig stehen nur 1. und 2. zur Diskussion, da die von mir in grossem Umfang unternommene Faktoranalyse noch nicht weit genug vorgeschritten ist, um sichere Schlüsse zu erlauben.

Die rein karyologischen Befunde könnten leicht dazu veranlassen, die Viererkomplexe für Tetravalente, also die sie konstituierenden Chromosomen für echt homolog zu halten. Geschlossene Ringe und Zickzacke aus gleich gross erscheinenden Einheiten (Abb. 4 k, n, p, r), ferner Figuren wie die in Abb. 4s und 4w gegebenen sind vielfach für echte Autotetraploide angegeben worden (vgl. BLAKESLEE 1929, DARLINGTON 1929, 1933, ERLANSON 1931, PHILP und HUSKINS 1931, KATTERMANN 1932). Die statistischen Zahlen der Tab. 1 und 2 mahnen aber zur Vorsicht, besonders wenn man bedenkt, dass derartige Anordnungen auch bei partieller Homologie, z.B. bei Duplikation endständiger Chromosomenstrecken sehr gut



möglich sind. Aus den erwähnten Tabellen geht hervor, dass die Frequenz der P.M.Z. mit Viererverbänden bei verschiedenen Verbindungen sehr verschieden sein kann. Würde das A-Genom ein oder zwei Chromosomen besitzen, die im B-Genom Homologe hätten, dann könnten die Zahlen bei der Neigung zur Komplexbildung im Weizen-*Aegilops*-Kreise nicht so starke Schwankungen aufweisen. Auch müssten sich die Verbände in diesem Fall bei den reinen Arten bemerkbarer machen, als dies der Fall ist. Dass häufige Auftreten offener Verbände von verschiedener Gestalt (Abb. 4 k-w) spricht auch gegen vollständige Homologie der betreffenden Chromosomen.

Die Fertilitätszahlen sind leider nicht ganz eindeutig, weil die fremden aus verschiedenen Ländern stammenden Weizen in sehr verschiedenem Grade das japanische Klima vertragen. Die Ertragsfähigkeit der Eltern macht sich in den Bastarden deutlich geltend und man kann sicher sagen, dass von einer Bastardsterilität schwerlich die Rede sein kann. So zeigt z.B. die Verbindung *T. dicoccum*  $\times$  *durum*, die ca. 31% P.M.Z. mit Viererverbänden aufwies, fast volle Fertilität (ca. 90%) in isoliertem Zustand. Von Wichtigkeit ist, dass auch in den weiteren Folgegenerationen, bis zu  $F_4$ , keine sterilen Pflanzen gefunden wurden.

Die oben besprochenen karyologischen Befunde und Fertilitätsfeststellungen berechtigen zu dem Schluss, dass ein bzw. zwei Chromosomen aus dem Genom A mit einem bzw. zwei Chromosomen aus dem Genom B gemeinsame Teile haben. Wie man sich des näheren den Aufbau dieser Chromosomen vorzustellen hat, muss vorläufig dahingestellt bleiben. Am einfachsten ist es, eine Duplikation anzunehmen, ohne sich selbstverständlich darauf festzulegen.

Bei der Annahme einer derartigen partiellen Homologie wird die Beantwortung der zweiten oben aufgeworfenen Frage möglich. Die Tatsache, dass die Tetrapartiten bei den reinen Arten entweder gar nicht oder nur sporadisch zu finden sind, kann nämlich so erklärt werden, dass die Partner der betreffenden A- bzw. B-Paare bei reinen Arten auf der ganzen Länge, also sowohl im kleineren duplizierten, allen 4 Chromosomen gemeinsamen Teil als auch im restlichen Stück, vollkommen identisch sind. Die dadurch ausgelöste starke Konkurrenzwirkung verhindert das Zusammentreten zu Komplexen und hat regelmässige Geminibildung zur Folge. Bei den Bastarden wären bei der oben gemachten Annahme die restlichen Stücke, wenn auch nur in geringem Grade, verschieden, wodurch die



Konkurrenzwirkung abgeschwächt und Paarung der betreffenden 4 Chromosomen (eines A-Paares mit einem B-Paare) ermöglicht wäre.

Diese Auffassung ist nicht etwa als sichergestellt anzusehen. Sie wird nur allen bisherigen Beobachtungen am besten gerecht und soll bis auf weiteres als Arbeitshypothese dienen, deren Wert sich bei künftigen Versuchen erweisen wird.

Zum Schluss möchte ich Herrn Prof. Dr. KIHARA für seine Leitung und für die Ueberlassung des Materials meinen herzlichsten Dank aussprechen. Auch Fräulein Dr. LILIENFELD bin ich für ihre wertvollen Ratschläge Dank schuldig.

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# Die japanischen Formen von *Fucus evanescens* AG.

Von Masaji NAGAI

Botanisches Institut der landwirtschaftlichen Fakultät der kaiserlichen  
Universität von Hokkaido zu Sapporo, Japan

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Mit 14 Textguren

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(Eingegangen am 7. Dezember, 1934)

Seit C. AGARDH zuerst (1820) *Fucus evanescens* aus Sachalin und Kamtschatka beschrieb, sind zahlreiche Formen dieser Art von J. AGARDH (3 neue Formen aus Grönland), KJELLMAN (1 neue Form aus dem murmanschen Meere, 3 aus Spitzbergen und 6 von der Bering-Insel), STRÖMFELT (1 neue Form von der Insel Island), und SETCHELL und GARDNER (2 neue Formen aus Alaska, und vom letzteren Autor 8 aus Alaska und von anderen Teilen der pazifischen Küste von Nordamerika) berichtet worden. Aus Japan führte YENDO 1907 vier Formen von dieser Art und eine andere Art, *Fucus inflatus* VAHL f. *edentatus* ROSENV., in einer Arbeit, „Fucaceae of Japan“, auf. Während meiner Untersuchung über die Algenflora der Kurilen, habe ich die Tatsache bemerkt, dass auf diesen Inseln mehr Formen von *F. evanescens*, als YENDO in seiner Arbeit gezeigt hatte, vorkommen. Um diese Formen von den Kurilen zur Genüge zu studieren, schien es mir notwendig, eine genauere Untersuchung über alle, auch in anderen Teilen von Japan vorkommende Formen zu machen. In Japan—ausser den Kurilen—kommen die Algen der Gattung *Fucus* in Sachalin, an der ochotskischen und pazifischen Küste von Hokkaido und der pazifischen Küste der nordöstlichen Teile von Honshu, die von kalten Meeresströmungen allein oder mit warmen Strömungen gemischt gespült werden, im allgemeinen vor. Meine Untersuchung zeigt nun, dass nur eine Art, *Fucus evanescens* AG. mit ihren 14 Formen (darunter 4 neue Formen), in Japan vorkommt. Die Form, welche YENDO als zu *F. inflatus* f. *edentatus* gehörig annahm, ist meines Erachtens besser als eine Form von *F. evanescens* zu betrachten. Meine Arbeit gründet sich hauptsächlich auf das Material, das ich selbst während meiner Reisen nach den Kurilen eingesammelt habe, und auf die *Fucus*-Exemplare in der Algensammlung des Herbariums der landwirtschaftlichen Fakultät der kaiser-

lichen Universität von Hokkaido. Ich habe auch die *Fucus*-Exemplare in den Algensammlungen des Herbariums der naturwissenschaftlichen Fakultät und der Fischereihochschule der hiesigen Universität, der kaiserlichen Universität und des kaiserlichen Fischereiinstitutes zu Tokyo, sowie auch die persönliche Sammlung OKAMURAS, und die YENDOS, die im Herbarium der kaiserlichen Universität zu Tokyo aufbewahrt wird, durchgegangen.

Zu grossem Dank verpflichtet fühle ich mich Herrn Prof. Dr. GARDNER von der Universität von Kalifornien für seine freundliche Uebersendung seines wertvollen Sonderabdrucks über die Gattung *Fucus* und der zahlreichen Algenexemplaren von Nordamerika, die den *Fucus*-Arten aufnehmen, sowie auch den Herren Prof. Dr. OKAMURA, NAKAI, YAMADA, HONDA, UEDA und TOKIDA, den Vorständen der obenangeführten Herbarien, für ihre Bereitwilligkeit, mit der sie mir diese wertvollen Sammlungen zur Verfügung gestellt haben. Ferner spreche ich meinen aufrichtigen Dank Herren Prof. Dr. MIYABE, ITO und TOCHINAI, für ihre stetige und liebenswürdige Unterstützung und Beratung aus, sowie auch dem Toshogu-Sanbiakunensai-Kinenkai für Ueberlassung eines Stipendiums, welches die Durchführung dieser Arbeit ermöglicht hat.

### *Fucus evanescens* AG.

Sp. Alg. I, pt. 1, 1820, pp. 92, 93; KJELLMAN, Spetsb. Thall. II, 1877, p. 40, Alg. Arct. Sea, 1889, p. 202; DE TONI, Syll. Alg. III, p. 201; SETCHELL & GARDNER, Alg. N. W. Amer., 1903, p. 681, Mar. Alg. Pacific Coast N. Amer. III, 1925, p. 681, pl. 106, 107; OKAMURA, Nippon Sorui Meii (1 Aufl.), 1903, p. 137; YENDO, Fucac. Japan, 1907, p. 14, pl. 1, Kaisan-Shokubutsugaku, 1910, p. 435, fig. 16, 131, 134, im OKAMURAS Nippon Sorui Meii (2 Aufl.), 1916, p. 189; GARDNER, Genus *Fucus*, 1922, p. 36, pl. 35–59; WORONICHIN,<sup>(1)</sup> Meeresalg. Kamtschatkas (Ins Jap. übersetzt), 1928, p. 139; SINOVA,<sup>(2)</sup> Meeresalg. Kamtschatkas, 1933, p. 28; OKADA, Kaiso Zufu, 1934, p. 64, pl. 61; HIGASHI, Nippon Kaiso Zufu, 1934, p. 37, pl. 37.

(1) Ich verlasse mich auf die Beschreibungen in „Plantae Cryptogames de Kamtschatka“, in den zweiten botanischen Nachrichten von TH. P. RIABUSCHINSKIS Expedition in Kamtschatka, welche von der Forschungsabteilung der Südmanchurischen Eisenbahngesellschaft ins Japanische übersetzt worden sind.

(2) SINOVA, E. S.: Nachricht der Expedition des Staatinstitutes für Hydrologie in den Meeren des Fernöstlichen Gebietes, Nr. 1 (Ber. Staatinstit. für Hydrologie, Leningrad, Bd. XVII), 1933, p. 7–42.

## Schlüssel der Formen

- I. Thallus hauptsächlich blätterig; Segmente breit, meist über 1 cm. breit.
- A. Rezeptakeln an den Enden scharf oder einigermassen gespitzt, oder etwas abgestumpft.
1. Rezeptakeln scharf gespitzt.
    - a. Rezeptakeln zwei- oder dreigabelig; Divergenzteile der Rezeptakeln etwas lang, weit und sternartig ausspreizend.....1. f. *stellatus*
    - b. Rezeptakeln zwei- oder dreigabelig, selten doppelt gabelig; Divergenzteile der Rezeptakeln kurz und nicht weit ausspreizend.....2. f. *rudis*
  2. Rezeptakeln einigermassen gespitzt, oder etwas abgestumpft.
    - a. Rezeptakeln nicht gross, mehr oder weniger tief zweigabelig verzweigt.
      - i. Divergenzteile schmal, meist gespitzt.....3. f. *intermedius*
      - ii. Divergenzteile breit, meist eiförmig, selten lineargespitzt.....4. f. *typicus*
    - b. Rezeptakeln sehr gross, meist seicht zweigabelig verzweigt; Divergenzteile der Rezeptakeln breit, etwas weit ausspreizend.....5. f. *magnificus*
- B. Rezeptakeln an den Enden stumpf oder rundlich.
1. Rezeptakeln meist stumpf.
    - a. Rezeptakeln meist zweigabelig.
      - i. Rezeptakeln meist seicht gabelig verzweigt; Divergenzteile der Rezeptakeln kurz und breit.....6. f. *paramushirensis*
      - ii. Rezeptakeln meist tief gabelig verzweigt; Divergenzteile der Rezeptakeln eiförmig, spindelförmig oder etwas länglich.....7. f. *pergrandis*
    - b. Rezeptakeln meist einfach, spindelförmig, selten zweigabelig.....8. f. *fusiformis*
  2. Rezeptakeln gewöhnlich rundlich.....9. f. *macrocephalus*
- II. Thallus schlank, nicht blätterig; Segmente schmal, meist unter 1 cm. breit.
- A. Rezeptakeln scharf gespitzt.
1. Thallus klein, ungefähr 5–7 cm. hoch; Rezeptakeln werden an dem dritten Aestchen von unten aus ausgebildet.....10. f. *pusillus*
  2. Thallus gross, über 10 cm. hoch; Rezeptakeln werden an dem vierten oder fünften Aestchen von unten aus ausgebildet.....11. f. *cornutus*
- B. Rezeptakeln an den Enden stumpf oder rundlich.
1. Rezeptakeln zylindrisch oder schmalspindelförmig.
    - a. Rezeptakeln gross, 2–5 × 0.4–0.7 cm. gross, an den beiden, vollkommenen Oberflächen mit zahlreichen Konzeptakeln versehen.....12. f. *cylindricus*
    - b. Rezeptakeln klein, 1.2–1.8 × 0.4–0.6 cm. gross, an den Rändern öfters ohne Konzeptakeln.....13. f. *marginatus*
  2. Rezeptakeln eiförmig, eirund, verkehrteiförmig, oder -herzförmig.....14. f. *irregularis*



1. *f. stellatus* GARDN.

Genus *Fucus*, 1922, p. 49, pl. 53; SETCH. & GARDN., Mar. Alg. Pacific Coast N. Amer. III, 1925, p. 687.

Thallus schlotterig, dichotomisch oder subdichotomisch verzweigt, in getrocknetem Zustande dunkelbraun gefärbt, 17 cm. hoch. Basalscheibe klein; Stengel schmal. Segmente etwas kurz, keilförmig, 6–10 mm. breit. Mittelrippen etwas breit und einigermaßen hervorragend, aber bisweilen undeutlich. Kryptostomata wenig,



Fig. 1. *Fucus evanescens* Ag. *f. stellatus* GARDN. Ein bei Airop, Sachalin, eingesammeltes Exemplar.  $\times$  ca.  $\frac{2}{3}$

nicht auffallend. Rezeptakeln deutlich abgegrenzt, zwei- oder dreigabelig, bisweilen doppelt gabelig, meistens mit weit und sternartig ausspreizenden und gespitzten Divergenzteilen versehen, 3.3–4 cm. lang. Konzeptakeln zahlreich, auffallend. Oogonien  $129-240 \times$

99–180  $\mu$ , meist 129–195  $\times$  99–135  $\mu$ . Antheridien 42–54  $\times$  13.5–16.5  $\mu$ .

*Hab.* Sachalin. Ostküste: Airop (MIYABE, 1906).

*Verbr.* Staat Washington, Nordamerika.

Von den Exemplaren in den Sammlungen des Herbariums der landwirtschaftlichen Fakultät der hiesigen Universität, traf ich ein am obenerwähnten Orte eingesammeltes Exemplar an, das ziemlich gut mit der Originalbeschreibung und Abbildung GARDNERS übereinstimmt.

## 2. *f. rudis* KJELLM.

Beringhafv. Algfl., 1889, p. 34; DE TONI, Syll. Alg. III, p. 202; GARDN. Genus *Fucus*, 1922, p. 53, pl. 57; SETCH. & GARDN., Mar. Alg. Pacific Coast N. Amer. III, 1925, p. 692; WORONICHIN, Meeresalg. Kamtschatkas, 1928, p. 143; SINOVA, Meeresalg. des Ochotsk. Meer.,<sup>(1)</sup> 1930, p. 103, Meeresalg. Kamtschatkas, 1932, p. 28; NAGAI,<sup>(2)</sup> Meeresalg. aus Kamtschatka, 1933, p. 16.

*Fucus vesiculosus* POST. et RUPR., Ill. Alg., 1840, Taf. 25.

Thallus sublederartig, dichotomisch oder teilweise einseitig verzweigt, 19–30 cm. hoch. Segmente etwas keilförmig, 8–20 mm., meist 10–15 mm. breit. Mittelrippen etwas breit, bisweilen aber undeutlich. Kryptostomata fehlend oder 5–15 pro Quadrat cm. an den Oberteilen der Segmente zerstreut. Rezeptakeln etwas lang, zwei- oder selten dreizackig, bisweilen doppelt gabelig verzweigt, an den Enden meistens gespitzt, 2.5–4.5 cm., meist 2.5–3 cm. lang, 6–25 mm., meist 9–12 mm. breit, nicht deutlich abgegrenzt. Konzeptakeln zahlreich, auffallend. Oogonien 114–180  $\times$  78–135  $\mu$ . Antheridien 36–51  $\times$  10.5–21  $\mu$ .

*Hab.* Kurilen. Insel Urup: Kobune (KIMURA, 1899, Herb. OKAMURAS). Insel Etorofu: Bettobu (NAGAI, 1930), Rubetsu (NAGAI, 1930, 1931). Insel Shikotan: Aimizaki (NAGAI, 1934), Notoro (NAGAI, 1934). Insel Kunashiri: Wennai (NOZAWA u. WATANABE, 1893).

Hokkaido. Prov. Nemuro: Tomoshiri (TANAKA, 1892). Prov. Oshima: Shirikishinai (MIYABE u. NOZAWA, 1890).

Sachalin. Westküste: Kap Nishinotoro (TOKIDA, 1932).

*Verbr.* Bering-Insel, Kamtschatka und Alaska.

(1) SINOVA, E. S.: Trav. Soc. Naturalist, Léningrad, LX, 3, 1930, p. 81–125.

(2) NAGAI, M.: Trans. Sapporo Nat. Hist. Soc., XIII, 1, 1933, p. 12–19.

Die Exemplare, die ich hier unter dem Namen *f. rudis* zusammenstelle, scheinen mir gut mit der Abbildung von *Fucus vesiculosus* in POSTELS und RUPRECHTS „Illustrationes Algarum“ übereinzustimmen; KJELLMAN hat letztere Formen als Synonyme zu *f. rudis* bestimmt. Soweit meine Beobachtungen reichen, wird diese Form



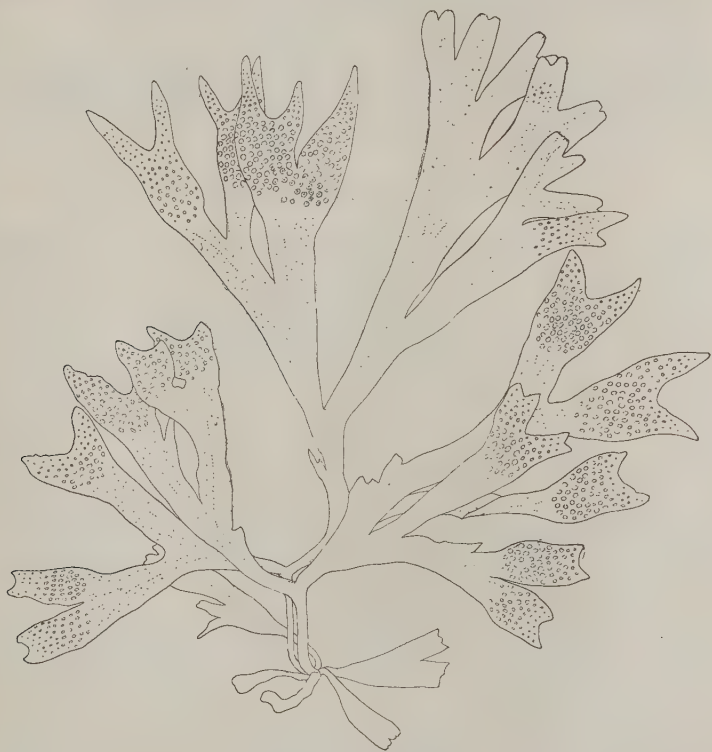
Fig. 2. *Fucus evanescens* AG. *f. rudis* KJELLM. Ein bei Aimizaki, Insel Shikotan, Kurilen, eingesammeltes Exemplar.  $\times$  ca. 1/2

hauptsächlich dadurch gekennzeichnet, dass die Rezeptakeln etwas lang sind, undeutlich abgegrenzt, und sich mitunter nicht regelmässig dichotomisch verzweigen, sondern dreigabelig oder teilweise einseitig. Sie schliesst sich, scheint es mir, am engsten an *f. intermedius* an.

3. *f. intermedius* GARDN.

Genus *Fucus*, 1922, p. 44; SETCH. & GARDN., Mar. Alg. Pacific Coast N. Amer. III, 1925, p. 688.

Thallus blätterig, 10–14 cm., selten bis zu 33 cm. hoch, dichotomisch verzweigt, in getrocknetem Zustande dunkelbraun gefärbt. Segmente keilförmig bis sublinear, 9–16 mm. breit. Mittelrippen



F 1 .. *Fucus evanescens* AG. *f. intermedius* GARDN. Ein bei Abashiri, Hokkaido, eingesammeltes Exemplar.  $\times$  ca.  $\frac{2}{3}$

etwas breit, beim grössten Teil der Segmente etwas hervorragend, an den Enden aber undeutlich. Alae etwas breit. Kryptostomata etwa 15 pro Quadrat cm. an den Oberteilen der Segmente zerstreut. Rezeptakeln seicht oder tief gabelig verzweigt, an den Basis etwas

breit, an den Enden gespitzt, 2–3 cm. lang, 9–12 mm. breit. Konzeptakeln zahlreich, auffallend. Oogonien  $96-151.2 \times 72-103.2 \mu$ . Antheridien  $31.2-43.2 \times 12-15.6 \mu$ . Paraphysen  $120-216 \times 8.4-9.6 \mu$ .

*Hab.* Kurilen. Insel Etorofu: Hitokappu-wan (NAGAI, 1930), Arimoe (NAGAI, 1930).

Hokkaido. Prov. Kitami: Abashiri (KOYAMA, 1915, Herb. OKAMURAS), Insel Rishiri (YENDO, 1899, Herb. YENDOS).

Sachalin. Ostküste: Motodomari (OTANI, 1930).

*Verbr.* Staat Washington, Nordamerika.

Die Exemplare, welcher an obenerwähnten Orten eingesammelt worden sind, scheinen mir ziemlich gut mit der Originalbeschreibung und Abbildung GARDNERS übereinzustimmen.

#### 4. *f. typicus* KJELLM.

Spetsb. Thall. II, 1877, p. 3, Alg. Arct. Sea, 1883, p. 202; SETCH. & GARDN., Alg. N. W. Amer., 1903, p. 282, Mar. Alg. Pacific Coast N. Amer. III, 1925, p. 683; GARDN., Genus *Fucus*, 1922, p. 51, pl. 56; WORONICHIN, Meeresalg. Kamtschatkas, 1928, p. 141.

Thallus lederartig, dichotomisch, in getrocknetem Zustande dunkelbraun gefärbt, ungefähr 16 cm. hoch. Segmente sublinear bis keilförmig, meist 6–9 mm. breit. Mittelrippen etwas breit, beim grössten Teil der Segmente einigermassen hervorragend, an den Enden aber undeutlich. Kryptostomata wenig, 10–15 pro Quadrat cm. an den Oberteilen der Segmente zerstreut. Rezeptakeln tief gabelig verzweigt, eiförmig oder etwas lineargespitzt, 2.1–3 cm. lang, 7–12 mm. breit. Konzeptakeln zahlreich, auffallend. Oogonien  $129-165 \times 96-120 \mu$ . Antheridien  $42-57 \times 12-16.5 \mu$ .

*Hab.* Hokkaido. Prov. Iburi: Mororan (YOSHIKAWA, 1883).

*Verbr.* Spitzbergen, Baffinsbai, Kara-Meer, Murmansches Meer, Alaska und Kamtschatka.

Von den Exemplaren, die ich in den verschiedenen Algensammlungen durchging, kann ich kein Exemplar, das auf diese Form bezüglich ist, antreffen, ausser dem am obenerwähnten Orte eingesammelten. Das Exemplar scheint mir aber etwas kräftiger als die Abbildung des Typusexemplares KJELLMANS in der Arbeit GARDNERS zu sein. Ich stelle für jetzt das Exemplar provisorisch zu dieser Form. Zur genaueren Bestimmung dieser Form ist in Zukunft Untersuchung zahlreicher Exemplare notwendig.





Fig. 4. *Fucus evanescens* AG. f. *typicus* KJELLM. Ein bei Mororan, Hokkaido, eingesammeltes Exemplar.  $\times$  ca. 1/2

### 5. f. *magnificus* GARDN.

Genus *Fucus*, 1922, p. 48, pl. 51, 52; SETCH. & GARDN., Mar. Alg. Pacific Coast N. Amer. III, 1925, p. 686.

Thallus blätterig, wiederholt dichotomisch oder teilweise einseitig verzweigt, in getrocknetem Zustande beim grössten Teil dunkelbraun gefärbt, 15–30 cm. hoch. Segmente linear bis etwas keilförmig, 7–13 mm. breit. Mittelrippen etwas breit und einigermaßen hervorragend, an den Enden der Segmente aber undeutlich. Kryptostomata fehlend oder wenig bis zu 50 pro Quadrat cm. auf den Oberseiten der Segmente zerstreut. Rezeptakeln deutlich abgegrenzt, gross, schwellend oder flach, gabelig oder selten doppelt gabelig verzweigt, an den Enden stumpf oder selten etwas gespitzt, 2,5–5 cm. lang, 10–28 mm. breit. Konzeptakeln zahlreich, auffallend. Oogonien  $120\text{--}180 \times 84\text{--}102 \mu$ . Antheridien ungefähr  $39 \times 10.2\text{--}13.5 \mu$ .

*Hab.* Kurilen. Insel Shumushu: Tenjin-iwa (NAGAI, 1932), Kataoka-wan (NAGAI, 1930). Insel Paramushir: Murakami-wan (NAGAI, 1930), Kakumabetsu (NAGAI, 1930). Insel Etorofu: Shana (NAGAI, 1934). Insel Shikotan: Notoro (NAGAI, 1934).

*Verbr.* Alaska bis zum Staate Washington, Nordamerika.

Die Exemplare, die ich hier zu dieser Form stelle, scheinen mir ziemlich gut (mit Ausnahme der etwas schmäleren Segmente), mit dem Exemplar aus dem Staate Washington, Nordamerika, übereinzustimmen, das von Prof. GARDNER dem Herbarium der hiesigen Universität geschenkt worden ist.

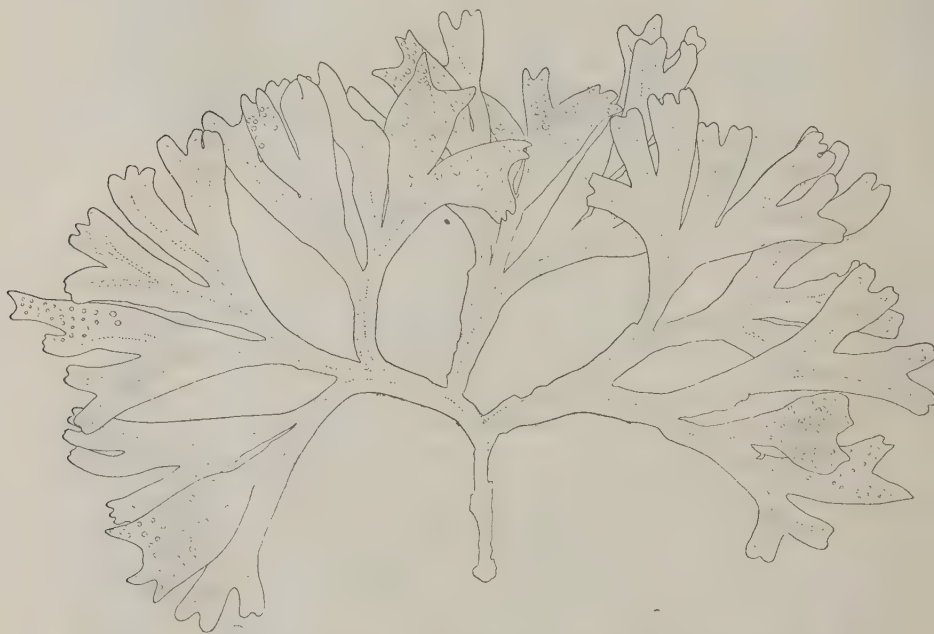


Fig. 5. *Fucus evanescens* AG. f. *magnificus* GARDN. Ein bei Murakami-wan, Insel Paramushir, Kurilen, eingesammeltes Exemplar.  $\times$  ca. 1/2

#### 6. f. *paramushirensis* NAGAI, f. nov.

Frons foliacea, subcoriacea, dichotoma, siccata fulvo-brunnea, 12–20 cm. alta; segmentis lineari-cuneatis, 7–10 mm. latis, costa latiuscula, in maxima parte segmenti aliquantum prominente, superne non prominente; cryptostomatibus nullis vel paucis, raro usque 15 per cm. quadratum in superioribus partibus segmentorum sparsis, siccatis prominentibus; receptaculis definitis, obovoideis, tenue vel

raro alte bifurcatis aut decomposito-furcatis, apicibus obtusiusculis, 2–3 cm. longis, 10–15 mm. latis; conceptaculis numerosis, prominentibus; oogonia  $105\text{--}159 \times 69\text{--}96 \mu$ ; antheridia  $33\text{--}55.5 \times 10.5\text{--}18 \mu$ .



Fig. 6. *Fucus evanescens* AG. f. *paramushirensis* NAGAI, f. nov. Ein bei Kakumabetsu, Insel Paramushir, Kurilen, eingesammeltes Exemplar.  $\times ca. 1/2$

*Hab.* Kurilen. Insel Paramushir: Kakumabetsu (NAGAI, 1930).

Thallus blättrig, sublederartig, dichotomisch verzweigt, in getrocknetem Zustande dunkelbraun gefärbt, 12–20 cm. hoch. Segmente linearkeilförmig, 7–10 mm. breit. Mittelrippen etwas breit, beim grössten Teil der Segmente einigermassen hervorragend, an den Enden aber undeutlich. Kryptostomata fehlend oder kärglich, selten ungefähr 15 pro Quadrat cm. an den Oberteilen der Segmente zerstreut, in getrocknetem Zustande auffallend. Rezeptakeln deutlich abgegrenzt, verkehrt eiförmig, seicht oder selten tief gabelig oder doppelt gabelig verzweigt, an den Enden etwas abgestumpft, 2–3 cm. lang, 10–15 mm. breit. Konzeptakeln zahlreich, auffallend. Oogonien  $105\text{--}159 \times 69\text{--}96 \mu$ . Antheridien  $33\text{--}55.5 \times 10.5\text{--}18 \mu$ .

Die vorliegende Form scheint mir einerseits zu *f. pergrandis*, anderseits zu *f. intermedius* am nächsten zu stehen. Die Rezeptakeln bei jener sind an den Enden rund oder stumpf, und die Divergenzteile ausspreizend, und bei dieser etwas schmal und gespitzt, jedoch ebenso wie bei *f. paramushirensis* abgestumpft und nicht ausspreizend. Durch diese Eigenschaften unterscheidet sich *f. paramushirensis* von den anderen ihr nahestehenden Formen.

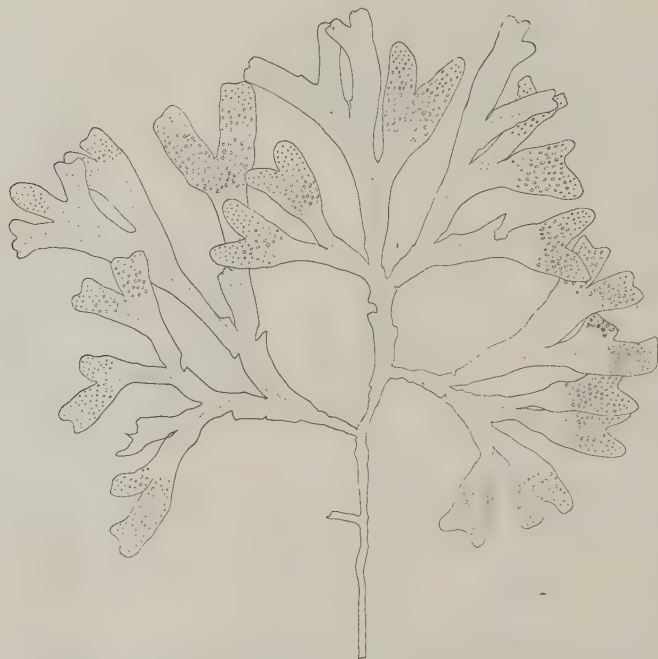


Fig. 7. *Fucus evanescens* AG. *f. pergrandis* KJELLM. Ein an der Broughton Bai, Insel Shimushir, Kurilen, eingesammeltes Exemplar.  $\times$  ca.  $1/2$

#### 7. *f. pergrandis* KJELLM.

Spetsb. Thall. II, 1877, p. 3, Alg. Arct. Sea, 1883, p. 202; DE TONI, Syll. Alg. III, p. 203; GARDN., Genus *Fucus*, 1922, p. 46, pl. 47, 48; SETCH. & GARDN., Mar. Alg. Pacific Coast N. Amer. III, 1925, p. 685.

? *Fucus evanescens* AG. f. *macrocephalus* YENDO (non KJELLM.),  
Fucac. Japan, 1907, p. 16.

Thallus sublederartig, wiederholt dichotomisch, in getrocknetem Zustande dunkelbraun gefärbt, meistens 15–20 cm. hoch. Segmente linear bis linearkeilförmig, 8–16 mm. breit. Mittelrippen etwas breit, beim grössten Teil der Segmente einigermaßen hervorragend, an den Enden aber meist undeutlich. Kryptostomata fehlend oder wenig an den Oberteilen der Segmente zerstreut. Rezeptakeln zahlreich, einfach oder zweigabelig. Divergenzteile eiförmig, spindelförmig oder etwas länglich, an den Enden gewöhnlich stumpf, 1,5–4,5 cm., meist 2–3 cm. lang, 8–17 mm. breit. Konzeptakeln zahlreich, auffallend. Oogonien  $117\text{--}210 \times 75\text{--}125 \mu$ . Antheridien  $36\text{--}54 \times 12\text{--}18 \mu$ .

*Hab.* Kurilen. Insel Paramushir: Murakami-wan (NAGAI, 1930), Suribachi-wan (NAGAI, 1932). Insel Shimushir: Broughton Bai (NAGAI, 1930). Insel Urup: Yoshinohama (JIMBO, 1891, Herb. OKAMURAS), Iema (KIMURA, 1899?, Herb. OKAMURAS). Insel Etorofu: Shana (NAGAI, 1934), Kamuikotan (NAGAI, 1934). Insel Shikotan: Notoro (NAGAI, 1934).

Hokkaido. Prov. Nemuro: Nemuro (MIYABE, 1884). Prov. Kushiro: Kushiro (MIYABE, 1894). Prov. Kitami: Monbetsu (ISHIKAWA, 1890).

Sachalin. Ostküste: Kashippo (TOKIDA, 1931).

*Verbr.* Spitzbergen und Nordamerika: Alaska bis zum Staate Washington.

Durch die Bereitwilligkeit von Dr. YAMADA konnte ich ein Exemplar aus Spitzbergen, welches KJELLMAN als zu dieser Form gehörig identifizierte, sehen. Es ist ein verkümmertes Exemplar mit ungefähr 1 cm. breiten Segmenten und wenigen, eiförmigen Rezeptakeln versehen. Das stimmt gut mit der Photographie des Exemplares KJELLMANS, welche von GARDNER auf Taf. 36 seiner Arbeit gegeben ist, überein. Diese Exemplare sind möglicherweise an derselben Fundstätte eingesammelt worden. GARDNER fand, dass die auf obiger Photographie abgebildeten Exemplare nicht gut mit der Originalbeschreibung und den Typusexemplaren KJELLMANS (Taf. 47 in der Arbeit GARDNERS) übereinstimmen. In seiner Arbeit ist eine andere Photographie der hier beschriebenen Form (Taf. 48) gegeben. Nach GARDNER sind die Exemplare dieser Tafel in Juneau, Alaska, eingesammelt worden und stimmen gut mit der Originalbeschreibung und den Typusexemplaren überein. In meiner Sammlung von den Kurilen



befinden sich zahlreiche Exemplare, die mir mit der Taf. 48 gut übereinzustimmen scheinen. Diese Exemplare identifizierte ich mit dieser Form. Von den Exemplaren, die in den Sammlungen OKAMURAS aufbewahrt sind, weise ich auch auf der Insel Urup eingesammelte Exemplare dieser Form zu. In seiner Arbeit, „Fucaceae of Japan“, beschrieb YENDO ein bei Kushiro, Hokkaido eingesammeltes Exemplar und wies es f. *macrocephalus* KJELLM. zu. Als ich die Exemplare, welche in dem Herbarium der hiesigen Universität und dem YENDOS sind, durchging, traf ich zwei solche Exemplare in jenem und eines in diesem Herbarium an. Das in dem Herbarium YENDOS angetroffene Exemplar wird von mir zu f. *cornutus* gestellt. Ein Exemplar in der Algensammlung der hiesigen Universität ist unfruchtbar, das andere, das von MIYABE bei Kushiro eingesammelt worden ist, mit etwas grossen, etwas tief zweigabelig verzweigten und an den Enden abgestumpften Rezeptakeln versehen. Wegen dieser Eigenschaften stelle ich dieses Exemplar, das möglicherweise von YENDO als f. *macrocephalus* behandelt worden ist, zu der hier beschriebenen Form.

#### 8. f. *fusiformis* NAGAI, f. nov.

? *Fucus evanescens* AG. f. *nana* et *bursigera* YENDO (non KJELLM.), Fucac. Japan, 1907, p. 16, pl. I, fig. 2.

Frons foliacea, membranacea, dichotoma vel partim subsecunda, siccata fulvo-brunnea, 16–28 cm. alta; segmentis superne linearibus, plerumque latioribus, inferne cuneatis, 7–14 mm., raro usque 25 mm. latis, costa latiuscula, in maxima parte segmenti aliquantum prominente, superne non prominente, alis membranaceis, cryptostomatibus numerosis, 20–50 per cm. quadratum in superioribus partibus segmentorum sparsis, siccatis prominentibus; receptaculis fusiformibus, fere integris, raro alte bifurcatis, definitis, subpedicelatis, 2.3–4 cm. longis, 8–12 mm. latis; conceptaculis numerosis, prominentibus; oogonia 120–174 × 90–114  $\mu$ ; antheridia 36–60 × 10.5–15  $\mu$ .

*Hab.* Sachalin. Ostküste: Airop (MIYABE, 1906), Higashishiraura (TOKIDA, 1931). Aniwa Bai: Kap Nishinotoro (TOKIDA, 1932), Chipessani (MIYABE, 1906), Merea (MIYABE, 1906), Kap Shiretoko (MIYABE, 1906).

Kurilen. Insel Shumshu: Tenjin-iwa (NAGAI, 1932). Insel Urup: Tokotan (NAGAI, 1931). Insel Kunashiri: Kap Atoiya (NAGAI u. SHIMAMURA, 1929), Rebun-iso (NAGAI u. SHIMAMURA,

1929), Seseeki nahe bei Wennai (NAGAI u. SHIMAMURA, 1929), Sokobetsu (NAGAI, 1931).

Hokkaido. Prov. Kitami: Esashi (FUKUSHIMA, 1892).



Fig. 8. *Fucus evanescens* AG. f. *fusiformis* NAGAI, f. nov. Ein bei Chipessani, Sachalin, eingesammeltes Exemplar.  $\times ca. 1/2$

Thallus blätterig, häutig, dichotomisch, teilweise etwas einseitig verzweigt, in getrocknetem Zustande dunkelbraun gefärbt, 16–28 cm. hoch. Segmente oben linear, unten keilförmig, 7–14 mm., selten bis zu 25 mm. breit, mitunter etwas weiter und häutig. Mittelrippen

etwas breit, beim grössten Teil der Segmente einigermassen hervorragend, an den Enden aber undeutlich. Kryptostomata zahlreich, 20–50 pro Quadrat cm. an den Oberteilen der Segmente zerstreut. Rezeptakeln deutlich abgegrenzt, subgestielt, einfach, spindelförmig, selten tief zweigabelig verzweigt, 2.3–4 cm. lang, 8–12 mm. breit. Konzeptakeln zahlreich, auffallend. Oogonien  $120-174 \times 90-114 \mu$ . Antheridien  $36-60 \times 10.5-15 \mu$ .

Bei dieser Form sind die rezeptakeltragenden Segmente öfters etwas kürzer als die Segmente, welchen die Rezeptakeln fehlen. Die vorliegende Form steht einerseits f. *pergrandis*, mit Rücksicht auf seinen etwas steifen Thallus und seine grossen spindelförmigen Rezeptakeln, anderseits *Fucus membranaceus* GARDN. mit Rücksicht auf seine haut- und blattartigen Segmente, am nächsten. Die Rezeptakeln dieser Form sind meistens einzeln und sehr selten zweigabelig verzweigend, bei f. *pergrandis* verzweigen sie jedoch öfters etwas tief, zweigabelig und spreizen ihre Divergenzteile aus. Diese Form unterscheidet sich auch von *F. membranaceus* durch das Vergehen der Mittelrippen an den Enden der Segmente. In einer Arbeit, „Fucaceae of Japan“, gibt YENDO eine Form, die er in Beziehung zu f. *nanus* und f. *bursigera* erachtet, und zeigt auch eine Abbildung (Taf. I, Fig. 2). Nach meiner Untersuchung dieses Exemplares, das im Herbarium der hiesigen Universität aufbewahrt wird, erachte ich diese Form mehr als ein verkümmertes Exemplar von f. *fusiformis*, als den obigen Formen nahestehend.

### 9. f. *macrocephalus* KJELLM.

Beringhafv. Algfl., 1889, p. 34; DE TONI, Syll.-Alg. III, p. 202; SAUNDERS, Alg. Harriman Exp., 1901, p. 433, pl. 62, fig. 1; SETCH. & GARDN., Alg. N. W. Amer., 1903, p. 282, Mar. Alg. Pacific Coast N. Amer. III, 1925, p. 684; GARDN., Genus *Fucus*, 1922, p. 45, pl. 45, 46; WORONICHIN, Meeresalg. Kamtschatkas, 1928, p. 144; SINOVA, Meeresalg. Kamtschatkas, 1932, p. 28.

Thallus sublederartig, wiederholt dichotomisch, in getrocknetem Zustande dunkelbraun gefärbt, 12–20 cm. hoch. Segmente einigermassen schmal, linear bis linearkeilförmig, 5–10 mm., meist 6–8 mm. breit. Mittelrippen einigermassen schmal, beim grössten Teil der Segmente etwas hervorragend, an den Enden aber undeutlich. Kryptostomata fehlend oder wenig an den Oberteilen der Segmente

zerstreut. Rezeptakeln zahlreich, deutlich abgegrenzt, einfach, seicht oder etwas tief gabelig verzweigt, eirund, eiförmig, verkehrtherzförmig, mit rundlichen, sehr selten mit etwas schmalen Enden



Fig. 9. *Fucus evanescens* AG. f. *macrocephalus* KJELLM. Ein bei Chikohai, Insel Etorofu, Kurilen, eingesammeltes Exemplar.  $\times$  ca. 2/3

gemischt versehen, 1–2.5 cm. lang, 10–18 mm. breit. Konzeptakeln zahlreich, auffallend. Oogonien  $114\text{--}141 \times 90\text{--}105 \mu$ . Antheridien  $36\text{--}48 \times 12\text{--}18 \mu$ . Paraphysen  $10.5\text{--}12 \times 204\text{--}300 \mu$  gross, aus einer Reihe von 5–6 Zellen bestehend.

*Hab.* Kurilen. Insel Paramushir: Murakami-wan (NAGAI, 1930), Chitose-wan (NAGAI, 1930). Insel Ketoi: Minami-ura (TATEWAKI u. TAKAHASHI, 1929). Insel Shimushir: Broughton Bai (NAGAI, 1930). Insel Etorofu: Chikohai (NAGAI, 1931), Shana (NAGAI, 1934). Insel Shikotan: Aimizaki (NAGAI, 1934).

*Verbr.* Bering-Insel und Alaska.

Die Exemplare, die an den obenangeführten Orten eingesammelt wurden, sind charakteristisch in Hinsicht auf ihre einigermaßen grossen, einfachen, eirunden, eiförmigen oder verkehrt herzförmigen Rezeptakeln, und weichen durch diese Eigenschaften von den anderen Formen ab. Diese Exemplare scheinen mir ziemlich gute Uebereinstimmung mit der Originalbeschreibung KJELLMANS und den Abbildungen, die SAUNDERS und GARDNER bezw. in ihren Arbeiten geliefert haben, zu zeigen.

#### 10. *f. pusillus* NAGAI, f. nov.

Frons pusilla, ca. 5–7 cm. alta, subcoriacea, dichotoma et partim subsecunda, siccata fulvo-brunnea; segmentis angustis, lineari-cuneatis, 2.5–6 mm., fere 3–4 mm. latis; costa angusta, in maxima parte segmenti paululum prominente, superne non prominente; cryptostomatibus paucis; receptaculis complanatis vel interdum inflatis, alte bifurcatis, plerumque paululum acuminatis, 8–13 mm.

longis, 2–4 mm. latis; conceptaculis minutis, prominentibus; oogonia 117–165  $\times$  75–102  $\mu$ ; antheridia 33–60  $\times$  12–16.5  $\mu$ .

*Hab.* Ostküste von Sachalin (Herb. OKAMURAS).

Thallus zwergartig, sublederartig, dichotomisch und teilweise etwas einseitig verzweigt, ungefähr 5–7 cm. hoch, in getrocknetem Zustande dunkelbraun gefärbt. Segmente schmal, 2.5–6 mm.,



Fig. 10. *Fucus evanescens* Ag. f. *pusillus* NAGAI, f. nov. Ein an der Ostküste von Sachalin eingesammeltes Exemplar.  $\times$  ca. 2/3



meist 3–4 mm. breit, linearkeilförmig. Mittelrippen schmal, beim grössten Teil der Segmente etwas hervorragend, an den Enden aber undeutlich. Kryptostomata kärglich. Rezeptakeln tief gabelig verzweigt und meist einigermassen gespitzt, 8–13 mm. lang, 2–4 mm. breit. Konzeptakeln sehr klein, zahlreich. Oogonien  $117-165 \times 75-102 \mu$ . Antheridien  $33-60 \times 12-16.5 \mu$ .

Von allen bereits beschriebenen Formen, scheint mir diese Form der von GARDNER beschriebenen f. *cuneatus* am nächsten zu stehen. Im Vergleich mit den Exemplaren von f. *cuneatus*, die von Prof. GARDNER dem Herbarium der hiesigen Universität geschenkt worden sind, ist seine Form in getrocknetem Zustande olivbraun, und wie bei der hier neu beschriebenen dunkelbraun gefärbt. Die Rezeptakeln bilden sich bei der von GARDNER beschriebenen Form an den zweiten Aestchen von unten aus, bei der hier vorliegenden Form aber meistens an den dritten. Bei dieser Form sind sie etwas schmaler als bei jener, und meistens sich allmählich verengernd und dichotomisch, teilweise auch einseitig verzweigt. Die hier neue beschriebene Form ist an den Exemplaren von OKAMURAS Sammlung ersichtlich, und die kleinste von allen in Japan angetroffenen Formen.

### 11. f. *cornutus* KJELLM.

Beringhafv. Algfl., 1889, p. 34; DE TONI, Syll. Alg. III, p. 202; GARDN., Genus *Fucus*, 1922, p. 50, pl. 55; SETCH. & GARDN., Mar. Alg. Pacific Coast N. Amer. III, 1925, p. 692 (p.p.).

Thallus schlank, sublederartig, dichotomisch verzweigt, in getrocknetem Zustande dunkelbraun gefärbt, 14–25 cm. hoch. Segmente gerade, linear bis linearkeilförmig, 4–8 mm. breit. Mittelrippen einigermassen schmal, beim grössten Teil der Segmente etwas hervorragend, an den Enden aber meistens undeutlich. Kryptostomata klein, kärglich, an den Oberteilen der Segmente zerstreut. Rezeptakeln zahlreich, deutlich abgegrenzt, gabelig oder doppelt gabelig verzweigt, an den Enden öfters scharf gespitzt oder selten einigermassen abgestumpft, mit mehr oder weniger seitenständig zurückgebogenen Divergenzteilen versehen, 2–3 cm. lang, 5–11 mm. breit. Konzeptakeln zahlreich. Oogonien  $111-180 \times 78-111 \mu$ . Antheridien  $31.5-52.5 \times 12-18.7 \mu$ .

*Hab.* Kurilen. Insel Alaid: Minami-ura (NAGAI, 1930). Insel Paramushir: Suribachi-wan (NAGAI, 1932), Murakami-wan (NAGAI,

1930), Kakumabetsu (NAGAI, 1930). Insel Ketoi: Minami-ura (TATEWAKI u. TAKAHASHI, 1929). Insel Etorofu: Shana (UEDA, 1927), Rubetsu (NAGAI, 1931).

Hokkaido. Prov. Hidaka (YENDO, 1909, Herb. YENDOS).

Sachalin. Westküste: Soni (TOKIDA, 1927).

Verbr. Bering-Insel, Kamtschatka und Alaska.

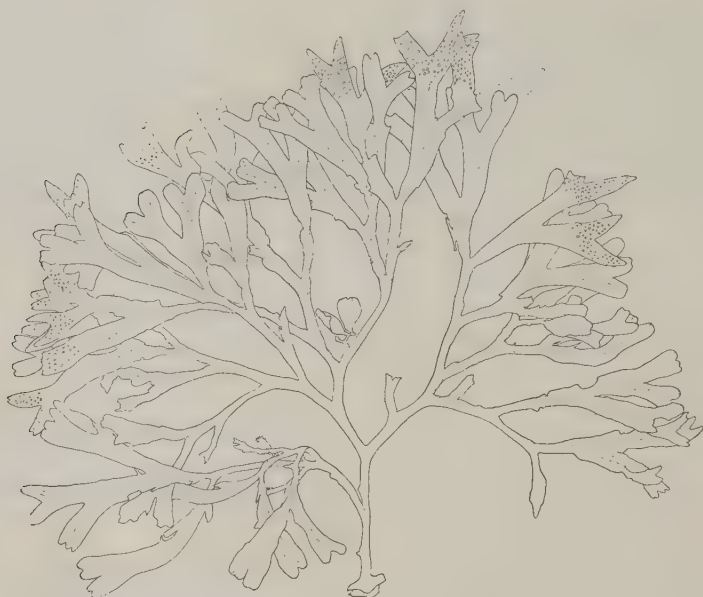


Fig. 11. *Fucus evanescens* Ag. f. *cornutus* KJELLM. Ein bei Shana, Insel Etorofu, Kurilen, eingesammeltes Exemplar.  $\times$  ca. 1/2

Von verschiedenen Algensammlungen, weichen die Exemplare, die an den obenangeführten Orten eingesammelt wurden, in Hinsicht auf ihren schlanken Thallus, die etwas schmalen Segmente und die schmalen und an den Enden öfters gespitzten Rezeptakeln von den anderen Formen ab. Nach der Originalbeschreibung KJELLMANS und der Photographie des Typusexemplares in der Arbeit GARDNERS (Taf. 55) zu urteilen, scheinen mir diese Exemplare mit f. *cornutus* übereinzustimmen. Von den Exemplaren, die im Herbarium YENDOS aufbewahrt werden, stelle ich die an dem obenerwähnten Orte eingesammelten Exemplare zu dieser Form.

12. *f. cylindricus* NAGAI, f. nov.

*Fucus inflatus* VAHL f. *edentatus* YENDO (non ROSENV.), Fucac. Japan, 1907, p. 17, pl. I, fig. 3.

?*Fucus evanescens* AG. f. *cornuta* YENDO (non KJELLM.), l. c., p. 16.

?*Fucus evanescens* HIGASHI (non AG.), Nippon Kaiso Zufu, 1934, pl. 37.

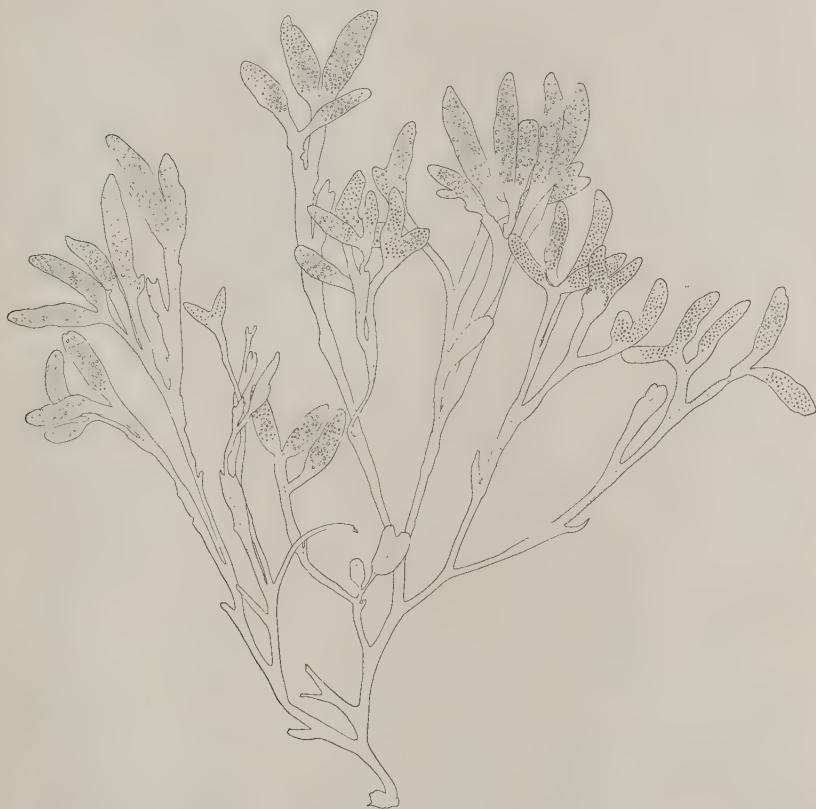


Fig. 12. *Fucus evanescens* AG. f. *cylindricus* NAGAI, f. nov. Ein bei Mororan, Hokkaido, eingesammeltes Exemplar.  $\times$  ca.  $1/2$

Frons caulescens, rigida, subcoriacea, dichotoma vel partim subsecunda, 11–33 cm. alta, luteola, siccata fulvo-brunnea; segmentis angustulis, strictis, linearibus vel raro lineari-cuneatis, 4–9 mm. latis,

costa angusta, paululum prominente, interdum percurrente, cryptostomatibus fere nullis; receptaculis numerosis, cylindraceis aut anguste fusiformibus, integris aut alte bifurcatis, definitis, apicibus obtusis vel obtusiusculis, 2–5 cm. longis, 4–7 mm. latis, conceptaculis prominentibus; oogonia  $96-168 \times 69-126 \mu$ ; antheridia  $39-66 \times 12-15 \mu$ .

*Hab.* Kurilen. Insel Etorofu: Iriribushi (NAGAI, 1934), Shana (NAGAI, 1934), Rubetsu (YENDO, 1903, Herb. YENDOS).

Hokkaido. Prov. Nemuro: Nemuro (KANO, 1887; Herb. Tokyo kaiserl. Univ.), Bentenjima, Nemuro (YENDO, 1903, Herb. YENDOS). Prov. Kushiro: Kushiro (KAWAKAMI, 1897, Herb. YENDOS), Akkeshi (HATTA, 1927; YAMADA, 1933). Prov. Hidaka: Shoya (TOKUBUCHI, 1892), Saruru (YAMADA, 1932), Urakawa (FUKUSHIMA, 1890), Shizunai (MIYABE, 1884). Prov. Ibur: Mororan (YOSHIKAWA, 1883; MIYABE, 1900; INO, 1933; YENDO, 1917, Herb. YENDOS). Prov. Oshima: Todohokke (MIYABE, 1894), Osatsube (NOZAWA, 1890).

Honshu. Prov. Rikuchu: Miyako (G. YAMADA, 1907, Herb. OKAMURAS). Prov. Rikuzen: Iwaizaki (WATANABE, 1899, Herb. OKAMURAS).

Thallus schlank, zweigartig, steif, sublederartig, dichotomisch oder teilweise etwas einseitig verzweigt, 11–33 cm. hoch, in getrocknetem Zustande dunkelbraun gefärbt. Segmente etwas schmal, gerade, linear oder selten linearkeilförmig, 4–9 mm. breit. Mittelrippen schmal, bisweilen bis zu den Enden der Segmente etwas hervorragend. Kryptostomata meistens fehlend. Rezeptakeln zahlreich, zylindrisch oder schmalspindelförmig, einfach oder tief gabelig verzweigt, deutlich abgegrenzt, an den Enden stumpf oder selten stumpfartig, 2–5 cm. lang, 4–7 mm. breit. Konzeptakeln auffallend. Oogonien  $96-168 \times 69-126 \mu$ . Antheridien  $39-66 \times 12-15 \mu$ .

In einer Arbeit „Fucaceae of Japan“ beschrieb YENDO eine *Fucus*-Art, die mit schmalem Thallus, schmalen Rezeptakeln und bis zu den Enden hervorragenden mittelrippetragenden Segmenten versehen ist. Er stellte seine Exemplare zu *Fucus inflatus* VAHL f. *edentatus* ROSENV., die BÖRGESSEN<sup>(1)</sup> in einer Arbeit „Marine Algae of Faeröes“ ausführlich beschrieben und abgebildet hat. Von den schmalen Formen, die an den pazifischen Küsten von Nordamerika gesammelt wurden, hat GARDNER in seiner Arbeit „The Genus *Fucus* on the Pacific Coast of North America“, fünf Formen unter dem Namen

(1) BÖRGESSEN, F.: Botany of the Faeröes, pt. II, 1903.

*Fucus edentatus* DE LA PYL. beschrieben. Nach den Beschreibungen und Abbildungen, die BÖRGESEN (S. 465–472 u. Text-fig. 90 u. 91) und GARDNER (S. 28–32 u. Taf. 20–26, 60) in ihren bezüglichen Arbeiten gegeben haben, und nach den Exemplaren zu urteilen, die vom letzteren Autor dem Herbarium der hiesigen Universität geschenkt worden sind, sind die Rezeptakeln dieser Arten gewöhnlich lanzenförmig und nach den Enden zu allmählich zugespitzt, aber bei den von YENDO behandelten Exemplaren linearspindelförmig und an den Spitzen im allgemeinen abgestumpft. Durch diese an diesen Exemplaren beobachteten Eigenschaften der Rezeptakeln weicht die vorliegende Form von *F. edentatus* DE LA PYL. oder *F. inflatus* f. *edentatus* ROSENV. ab. Bei dieser Form sind die Rezeptakeln, wenn reif, an beinahe allen Segmenten reichlich gebildet. Die Mittelrippen sind, wie YENDO zeigt, bisweilen verhältnismässig deutlich hervorragend, bis zu den Terminalenden der Segmente. Obgleich solche Eigenschaften der Mittelrippen erscheinen, so ist diese Form, wie mir scheint, doch in verschiedener Hinsicht besser als eine neue Form von *F. evanescens* als eine andere Art zu behandeln. Die vorliegende Form zeigt eine Annäherung an f. *marginatus*, weicht aber, wenigstens was die Grösse der Rezeptakeln betrifft, von dieser ab. In dem Herbarium der hiesigen Universität wird auch ein Exemplar aufbewahrt, das YENDO, wie mir scheint, in seiner Arbeit in Beziehung zu f. *cornuta* behandelte. Das Exemplar hat, wie YENDO zeigt, einige fragmentarische, etwas gereifte Rezeptakeln ausgebildet. Diese Rezeptakeln sind schmalspindelförmig, einfach oder tief gabelig verzweigt, an den Enden einigermassen gespitzt, und an der Basis deutlich abgegrenzt. Sie sind in der Grösse 5–8 cm. auf 6–10 mm. gemessen worden. In seiner Arbeit „Beringhafvets Algflora“, beschrieb KJELLMAN die Rezeptakeln von f. *cornutus* „receptaculis sublimitatis, usque 4 cm. longis, 5–10 mm. crassis, turgidis, decomposito-furcatis, ramis inferioribus subcylindricis, summis subcoriaceis“; demnach weicht dieses Exemplar durch die Grösse und den Verzweigungsmodus der Rezeptakeln von f. *cornutus* ab. Dieses Exemplar ist auch mit f. *longifructus* SETCH. et GARDN. verwandt, weicht aber durch seinen Verzweigungsmodus von jenem ab. Meines Erachtens ist dieses Exemplar neben die hier neu beschriebene Form f. *cylindricus* f. *nova* zu stellen. Nach der Abbildung auf Taf. 37 in der Arbeit HIGASHIS zu urteilen, scheint mir sein Exemplar auch in Hinsicht auf den zylindrischen Rezeptakeln mit dieser Form übereinzustimmen.



13. *f. marginatus* GARDN.

Genus *Fucus*, 1922, p. 42, pl. 42; SETCH. & GARDN., Mar. Alg. Pacific Coast N. Amer. III, 1925, p. 690.

*Fucus evanescens* AG. f. *dendroides* NAGAI (non STRÖMF.), Meeresalg. aus Kamtschatka, 1933, p. 16.

? *Fucus evanescens* AG. f. *angusta* YENDO (non KJELLM.), Fucac. Japan, 1907, p. 16, pl. I, fig. 1.

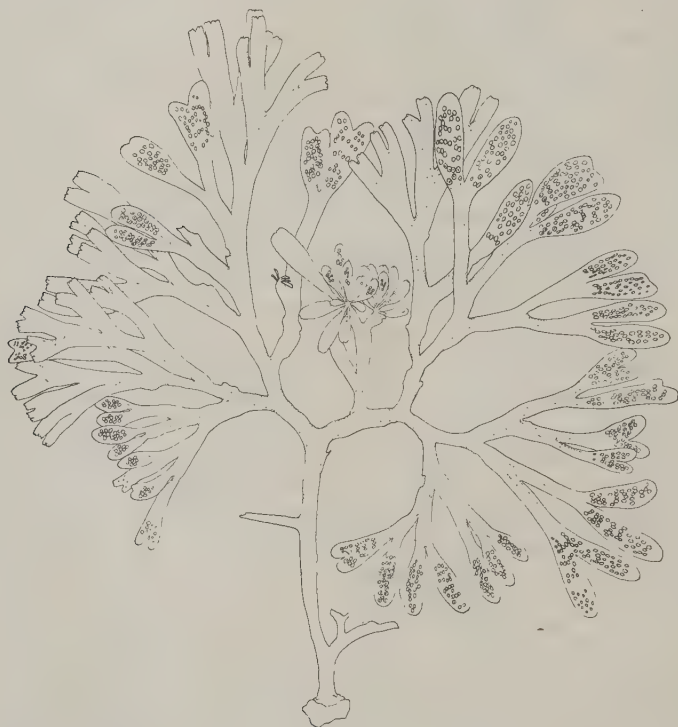


Fig. 13. *Fucus evanescens* AG. f. *marginatus* GARDN. Ein bei Minami-ura, Insel Ketoi, Kurilen, eingesammeltes Exemplar.  $\times$  ca.  $\frac{2}{3}$

Thallus schlank, zweigartig, steif und sublederartig, regelmässig dichotomisch, in getrocknetem Zustande dunkelbraun gefärbt, 14–21 cm. hoch. Segmente linear bis linearkeilförmig, schmal, gerade, etwas lang, 3–15 mm. breit. Mittelrippen auffallend, schmal, selten etwas hervorragend bis zu den Enden der Segmente. Kryptostomata wenig oder mitunter ganz fehlend. Rezeptakeln zahlreich, schmal-

spindelförmig, einfach oder tief gabelig verzweigt, an den Enden gewöhnlich stumpf, 1.2–1.8 cm. lang, 4–6 mm. breit. Konzeptakeln klein, auffallend. Oogonien  $105\text{--}165 \times 69\text{--}114 \mu$ . Antheridien  $30\text{--}46.5 \times 9\text{--}16.5 \mu$

*Hab.* Kurilen. Insel Shumushu: Kataoka-wan (Herb. OKAMURAS). Insel Ketoi: Minami-ura (TATEWAKI u. TAKAHASHI, 1929). Insel Shimushir: Broughton Bai (NAGAI, 1930). Insel Etorofu: Bettobu (IGARASHI, 1892).

Sachalin. Ostküste: Chirie (KITAHARA, 1912, Herb. OKAMURAS).

*Verbr.* Alaska und Kamtschatka.

In den Sammlungen des Herbariums der hiesigen Universität werden zwei Exemplare aus Alaska, welche GARDNER als zu dieser Form gehörig identifizierte, aufbewahrt. Von den an den obenangeführten Orten eingesammelten Exemplaren scheinen mir die auf der Insel Ketoi angetroffenen in mehrfacher Hinsicht ziemlich gut in Uebereinstimmung mit der Originalbeschreibung und den Exemplaren GARDNERS zu sein. Bei diesen und den Exemplaren aus Sachalin, sind die Rezeptakeln verhältnismässig reichlich gebildet. Die noch nicht zur Genüge gereiften Rezeptakeln sind an den Rändern öfters ohne Konzeptakeln. Nur bei einigen wenigen Exemplaren zeigen die gereiften nicht gut diese Eigenschaft. Bei diesen Exemplaren beobachtete ich die Segmente schmal und die Mittelrippen mitunter verhältnismässig deutlich bis zu den Terminalenden der Segmente hervorragend. In seiner Arbeit „Fucaceae of Japan“ hatte YENDO ein am Onnebetsu in der Provinz Kitami, Hokkaido, eingesammelten *Fucus* beschrieben und abgebildet (Taf. I, fig. 1), welcher von ihm zu *f. angusta* KJELLM. gestellt wurde. Das Exemplar, welches YENDO bestimmt hatte, wird in dem Herbarium der hiesigen Universität aufbewahrt. Betreffs dieser Form weist GARDNER darauf hin, dass in Hinblick auf die Grösse der Rezeptakeln und die Auffälligkeit der Mittelrippen das Exemplar YENDOS hauptsächlich von *f. angustus* KJELLM. abweicht, im Vergleich mit den Exemplaren KJELLMANS, welche von der Vega Expedition nahe bei Tjapka eingesammelt und dann von ihm dem Herbarium der Universität von Kalifornien übergeben worden sind. Nach reiflicher Ueberlegung entschliesse ich mich, diese Exemplare nahe zu der vorliegenden Form zu stellen. Im vorigen Jahre habe ich in einer kleinen Arbeit, „Meeresalgen aus Kamtschatka“, zwei Formen, namentlich *f. rudis* und *f. dendroides* unter dem Namen *Fucus evanescens* AG. beschrieben. Unter diesen Formen erachte ich jetzt

die zu letzterer Form gestellten Exemplare als mit der vorliegenden Form identisch.

#### 14. *f. irregularis* KJELLM.

Beringhafv. Algfl., 1889, p. 35; GARDN., Genus *Fucus*, 1922, p. 54; SETCH. & GARDN., Mar. Alg. Pacific Coast N. Amer. III, 1925, p. 693; WORONICHIN, Meeresalg. Kamtschatkas, 1928, p. 146; SINOVA, Meeresalg. Kamtschatkas, 1932, p. 29.



Fig. 14. *Fucus evanescens* AG. f. *irregularis* KJELLM. Ein bei Chikohai, Insel Etorofu, Kurilen, eingesammeltes Exemplar.  $\times ca. 2/3$

Thallus klein, sublederartig, mehr oder weniger unregelmässig dichotomisch verzweigt und verdreht, in getrocknetem Zustande dunkelbraun gefärbt, 6–11 cm. hoch. Segmente schmal, linear, ungefähr 2.5–4 mm. breit. Mittelrippen schmal, bisweilen bis zu den Enden der Segmente etwas hervorragend. Kryptostomata fehlend oder kärglich. Rezeptakeln klein, einfach oder gabelig, eiförmig, verkehrt-eiförmig, eirund oder verkehrtherzförmig, deutlich

abgegrenzt, 1–1.4 cm. lang, ungefähr 5 mm. breit. Konzeptakeln klein und auffallend. Oogonien  $155-210 \times 90-141 \mu$ . Antheridien  $27-54 \times 15-19.5 \mu$ . Paraphysen  $240-330 \times 12-15-24 \mu$ .

*Hab.* Kurilen. Insel Ketoi: Minami-ura (TATEWAKI u. TAKAHASHI, 1929). Insel Urup: Tokotan (NAGAI, 1930). Insel Etorofu: Moyoro (NAGAI, 1931), Chikohai (NAGAI, 1931), Bettobu (IGARASHI, 1892).

*Verbr.* Bering-Insel und Kamtschatka.

Mit Rücksicht auf den mehr oder weniger unregelmässig dichotomisch verzweigten Thallus, sowie auch die Formen und die Grösse der Rezeptakeln, stelle ich die an obenangeführten Orten eingesammelten Exemplare zu dieser Form.

# Karyological comparisons of haploid plants from octoploid *Aegilotriticum* and diploid wheat

By Yoshiwo KATAYAMA

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With 88 text-figures

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(Received December 13, 1934)

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## Introduction

KIHARA and KATAYAMA (1931) reported previously on the formation of *Aegilotriticum forma fertilis* No. 3. The original plant was obtained in 1929 in the  $F_2$  progeny of tetraploid hybrids between *Triticum dicoccoides* var. *Kotschyianum* ( $n=14$ ) and *Aegilops ovata* ( $n=14$ ). The diploid chromosome number of the  $F_1$  plant was 28, corresponding to the sum of the haploid numbers of the parents. The fertile *Aegilotriticum* ( $2n=56$ ), above mentioned, resulted from diploid gametes from these  $F_1$  individuals.

The constant octoploid *Aegilotriticum* has been cultivated ever since by the writer. In 1931, a haploid plant was found among 68 individuals that had originated from grains obtained from bagged spikes (*cf.* KIHARA and KATAYAMA, 1932). A haploid was obtained also in 1934. Although these haploid plants correspond to  $F_1$  individuals, certain differences in the haploids and  $F_1$  were observed.

In 1932, KIHARA and KATAYAMA, on the other hand, found 3 haploid individuals in progenies from X-rayed and bagged spikes

of *T. monococcum*. In the following year the junior author (KATAYAMA, 1934 a-b) obtained also many haploids in this diploid species by means of X-ray treatment.

Thus certain karyological comparisons were made of these haploids from two different species, *Aegilotriticum* and *T. monococcum*, and of the  $F_1$  plant of *T. dicoccoides*  $\times$  *Ae. ovata*.

### Haploid *Aegilotriticum*

In meiosis of the haploid *Aegilotriticum* obtained in 1931, the writer observed 27 univalent chromosomes, and one small fragment from which the greater part of a chromosome had been lost (Fig. 33, etc.), which was near to  $n-1$  condition. Although, strictly speaking, this plant cannot therefore be called a haploid, the writer desires to call it so (haploid *Aegilotriticum a*) for the sake of convenience. The haploid plant obtained in 1934, and which had exactly 28 univalent chromosomes (Fig. 37, etc.), is called haploid *Aegilotriticum b* in this paper.

In appearance the haploid individuals were rather slender compared with the  $F_1$  plant<sup>(1)</sup> from *Ae. ovata* crossed with *T. dicoccoides*. This relation was clearer in haploid *a* than in *b*. A photograph of spikes from fertile *Aegilotriticum*, haploid *Aegilotriticum*, and  $F_1$  is shown in Fig. 1. The spike of haploid *b* was almost the same as that of  $F_1$ , although the spike of *a* was reduced somewhat. We could see no special differences in any of the other morphological points.

KIHARA (1929) has already reported on the frequency of bipartite chromosomes in the  $F_1$  generation. The bipartite was observed usually in the meiosis of  $F_1$  plants, although the number differed according to the time of fixation and many cells had only univalent chromosomes. The number of bipartites in a cell varied from one to six. In haploid *a* the number of bipartites showed a much lower frequency. If they did occur, only one was seen in a cell. In haploid *b* we sometimes observed three bipartites in a cell. Some figures of cells containing bipartite chromosomes in  $F_1$  and haploid individuals are shown in Figs. 14-20, 31-36, and 40-42, together with

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(1) When no mention is made in this paper on the direction of the cross of  $F_1$  plants, it is understood that the direction was *Ae. ovata* ( $\varnothing$ )  $\times$  *T. dicoccoides* ( $\sigma$ ) and also that these  $F_1$  individuals were grown in 1931. This direction is a reciprocal of the cross in the original formation of this *Aegilotriticum* No. 3.



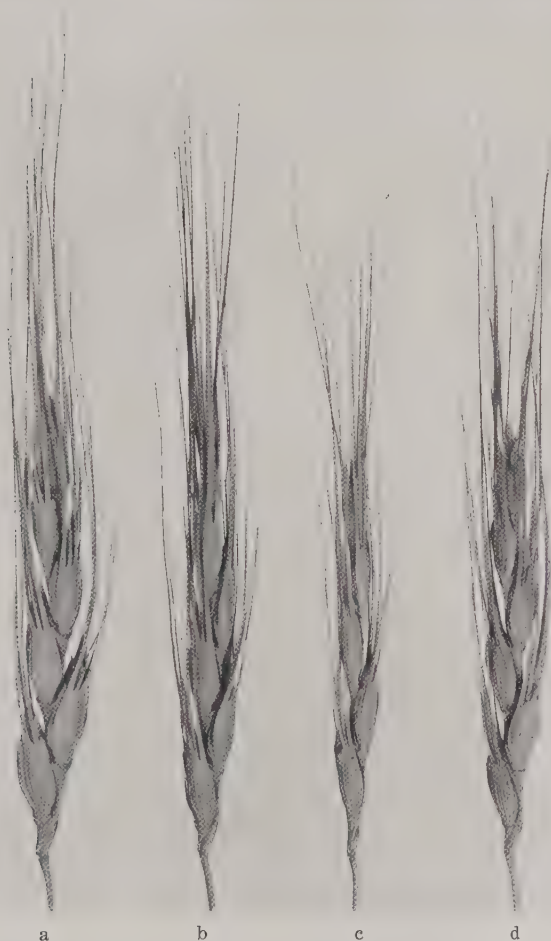


Fig. 1. Spikes from *Aegilotriticum* and  $F_1$  (*Ae. ovata*  $\times$  *T. dicoccoides*). Natural size. a, Fertile *Aegilotriticum*. b,  $F_1$ . c, Haploid *Aegilotriticum* a ( $2n = 27 + f$ ). d, Haploid *Aegilotriticum* b ( $2n = 28$ ).

some irregular ones. The result of observations of the bipartite chromosomes is shown in Table 1 with that of KIHARA's observations of the  $F_1$  generation.

TABLE 1. Frequency in the number of bipartite chromosomes observed in the meiosis of  $F_1$  hybrid (*Triticum dicoccoides*  $\times$  *Aegilops ovata*) and of haploid *Aegilotriticum*

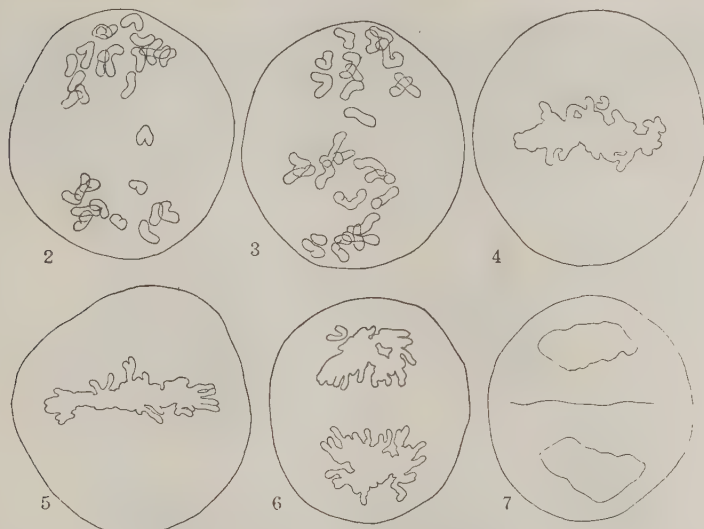
	Date of fixation	Number of bipartite chromosomes							Total	Author
		0	1	2	3	4	5	6		
$F_1^*$ ( <i>T. dicoccoides</i> $\times$ <i>Ae. ovata</i> ) ( $2n = 28$ ) 1928	7/V	<b>73</b>	23	4	0	0	0	0	100	KIHARA (1929)
	10/V	1	18	<b>36</b>	27	11	6	1	100	
Haploid <i>Aegilotriticum a</i> ( $2n = 27 + f$ ) 1931	27/V	<b>92</b>	8	0	0	0	0	0	100	The writer
	3/VI	<b>90</b>	10	0	0	0	0	0	100	
Haploid <i>Aegilotriticum b</i> ( $2n = 28$ ) 1934	28/V	<b>74</b>	18	6	2	0	0	0	100	The writer

\* Contains tripartite chromosomes.

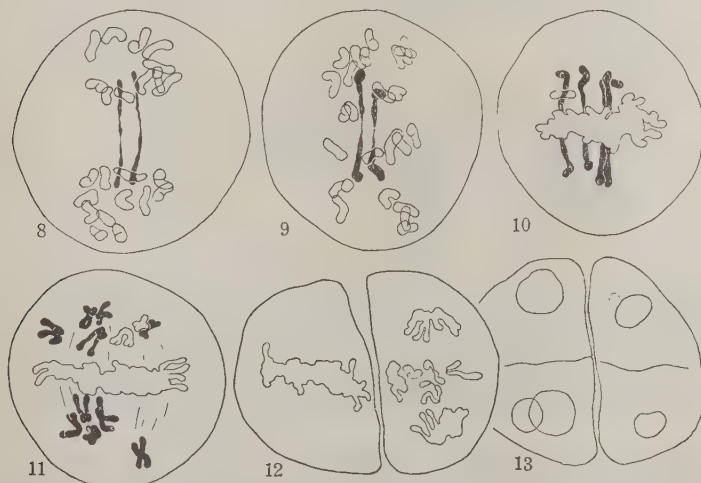
The movement of univalent chromosomes in the original  $F_1$  plant has been reported by KIHARA and KATAYAMA (1931). Their object was to study the formation of diploid pollen, and they pointed out the following two processes of formation: (1) In one process all the chromosomes are univalent and they all divide homotypically at the first division, i.e., with omission of the heterotypic division. (2) In the other case the first division ceases and a restitution nucleus results, and then homotypic division follows. Of these two processes the former does not often occur, whereas the latter may be expected to occur somewhat readily under certain external conditions. It is therefore assumed that the functional diploid pollen in these  $F_1$  plants is contributed after occurrence of the regression phenomenon at the first division.

With the same preparation, the writer made further observations on movements during the first and second divisions. In this way he verified the previous observation. In the early metaphase, the univalents concentrated at different poles, after which many of them orientated to the equatorial region. But since the modes of the chromosome movement in  $F_1$  plants were various, and as the chromosomes divided irregularly, we are able to describe only their general movements. From this present observation three cases are categorised.

(1) When all the chromosomes are univalent at the first division, they orientate to the equatorial region and split into monads and

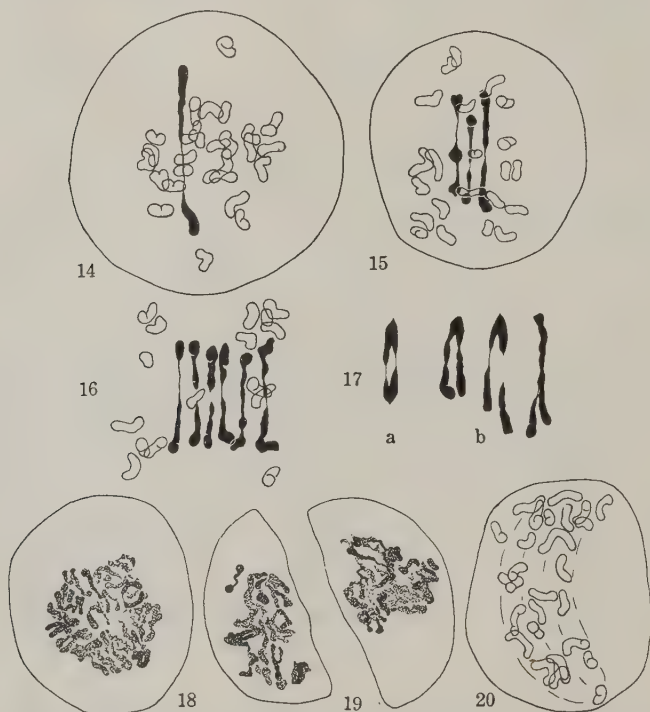


Figs. 2-7. Typical movement of univalents in  $F_1$  (*T. dicoccoides*  $\times$  *Ae. ovata*). First division.  $\times 1600$ . 2, Early metaphase. 3, Transitory stage. 4, Metaphase. 5, Early anaphase. 6, Anaphase. 7, Telophase.



Figs. 8-13.  $F_1$  (*T. dicoccoides*  $\times$  *Ae. ovata*). Movement of chromosomes in the presence of both univalents and bipartites.  $\times 1600$ . 8-11, First division. 12, Second division. 13, Pollen tetrad.

move away to different poles (Figs. 2-7). Since we have not been able thus far to observe any double splitting of univalent chromosomes in wheat species, it is supposed that the second division does not occur. (2) When many bipartites occur, the chromosomes move as in the usual way in wheat hybrids. First, the bipartites divide at the

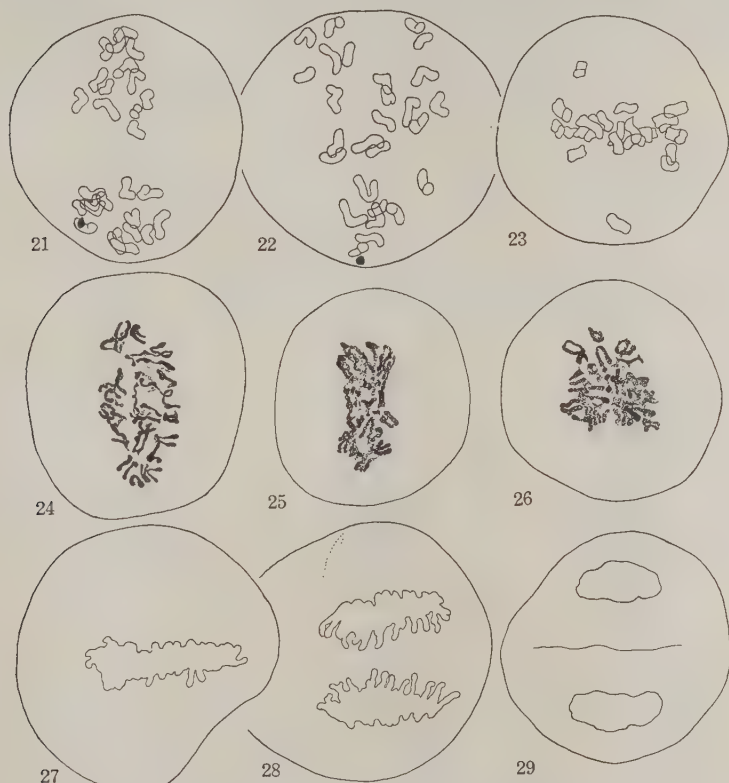


Figs. 14-17.  $F_1$  (*T. dicoccoides*  $\times$  *Ae. ovata*). Pairing of chromosomes at the first metaphase.  $\times 1600$ . 14,  $26_I + 1_{II}$ . 15,  $22_I + 3_{II}$ . 16,  $16_I + 6_{II}$ . 17, Different figures of bipartite (a) and tripartite (b).

Figs. 18-20.  $F_1$  (*T. dicoccoides*  $\times$  *Ae. ovata*). Cells whose chromosomes are going to a restitution nucleus and a cell with a curved spindle.  $\times 1600$ . 18, Regression occurring at the first division. 19, Regression occurring at the second division. 20, A cell at the first division showing curved spindle.

first division, after which the univalents that orientated on the equatorial plane separate homotypically. In the second division, all the chromosomes are generally orientated to the equatorial region. Usually the dyad chromosomes divide first, after which the monads

distribute at random to the different poles (Figs. 8-13). (3) Regression phenomenon occurs in both cases (1) and (2) (Figs. 18-19). Diploid pollen grains originate where the restitution nuclei are form-



Figs. 21-29. Typical movement of univalents in haploid *Aegilotriticum a* ( $2n = 27 + f$ ).  $\times 1600$ . 21-26, First division. 21, Early metaphase. 22, Transitory stage clearly showing  $27_1 + f$ . 23, Formation of nuclear plate at the metaphase. 24-26, Different figures going to a restitution nucleus. 27-29, Second division. 27, Later metaphase. 28, Anaphase. 29, Telophase.

ed at the first meiotic division and in the second division the chromosomes divide homotypically. If regression occurs in the second division, the resultant cells would have various numbers of chromosomes. These dyad cells do not usually become functional pollen grains.



In the haploid *Aegilotricum*, the movement of univalent chromosomes was somewhat uniform compared with that of the  $F_1$  generation. Usually the univalents in haploid *b* orientated to the equatorial region and split homotypically as in case (1) of  $F_1$  (Figs. 37–39). In many cells of haploid *Aegilotricum a*, the chromosomes that had

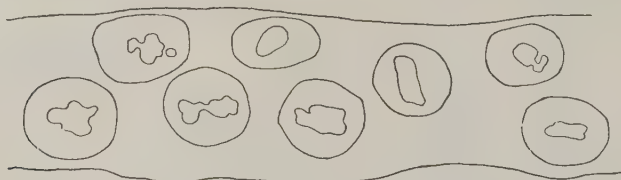
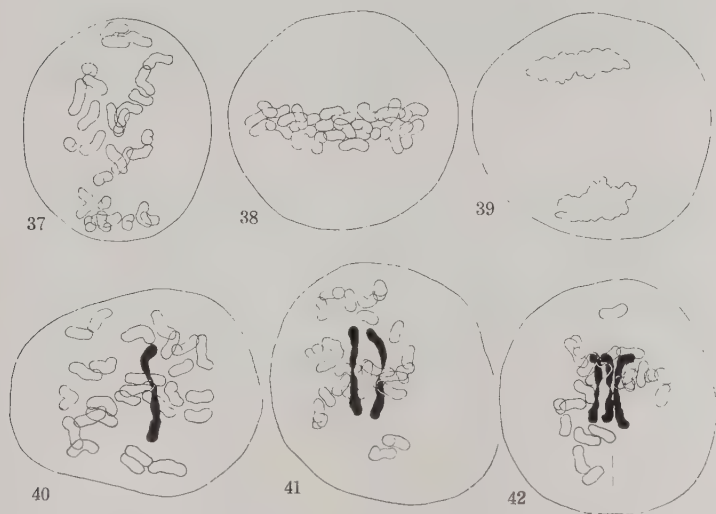


Fig. 30. Haploid *Aegilotricum a* ( $2n = 27+f$ ). PMCs with a restitution nucleus of different shapes in a part of an anther.  $\times$  ca. 550.



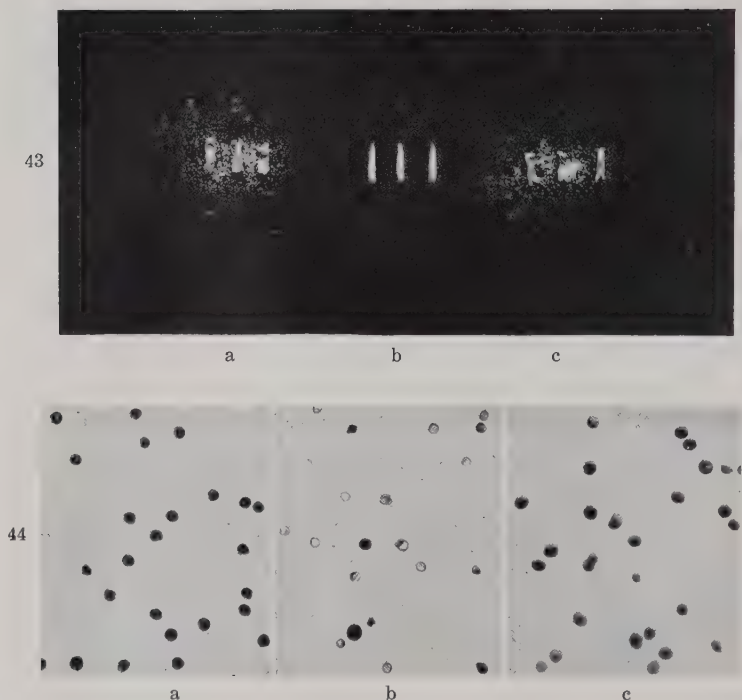
Figs. 31–36. Haploid *Aegilotricum a* ( $2n = 27+f$ ). Figures of bipartite chromosomes and spindles at the first division.  $\times 1600$ . 31, Early metaphase with a bipartite chromosome. Two univalents connected also at one end (a), the end-to-end connection remaining in the prophase. 32, Transitory stage with one bipartite chromosome. 33, Early metaphase with a fragment. 34–36, Various irregular figures in the spindle.

orientated to the equatorial region at the first division ceased dividing and resulted in a restitution nucleus (Figs. 24–26 and 30). Cytokinesis sometimes occurred in some of the cells. In the second division, each chromosome splits homotypically, and dividing, went to opposite poles. The resultant dyad cells should have contained the greater number of chromosomes that were included in the respective mother cells. This typical case is shown in Figs. 21–29.



Figs. 37–42. Meiotic figures from haploid *Aegilotriticum b* ( $2n = 28$ ). First division. Acetocarmine preparation.  $\times 1100$ . 37, Transitory stage showing 28I. 38, Formation of nuclear plate at the metaphase. 39, Later anaphase. 40,  $26I + 1II$ . 41,  $24I + 2II$ . 42,  $22I + 3II$ .

Haploid *Aegilotriticum a* opened its anthers and discharged many pollen grains, which was not seen in  $F_1$  plants or in haploid *b*. This will be due to the fact that chromosomes in haploid *a* show usually the regression phenomenon at first division. It may be assumed that in such resultant dyad cells, conditions in the nucleus are appropriate for the formation of pollen grains. Figures illustrating the opening of anthers in fertile and haploid (*a*) *Aegilotriticum* and in  $F_1$  are given in Figs. 43–44. Table 2 gives the counts of pollen that were plump or had contents in them.



Figs. 43-44. Microphotographs from *Aegilotriticum* and  $F_1$  (*Ae. ovata* × *T. dicoccoides*). 43, Opening of anthers. ×2. 44, Pollen grains. ×65. a, Fertile *Aegilotriticum*. b,  $F_1$ . c, Haploid *Aegilotriticum a* ( $2n = 27+f$ ).

TABLE 2. Percentages of plump pollen grains in *Aegilotriticum* and its haploids, and in  $F_1$  (*Aegilops ovata* × *Triticum dicoccoides*)

	Total number of pollen examined	Number of plump pollen	Number of empty pollen	Percent of plump pollen
<i>Aegilotriticum</i>	2000	1530	470	76.50
Haploid <i>a</i>	2000	1023	977	51.15
Haploid <i>b</i>	200	25	175	12.50
$F_1$	2000	174	1826	8.70

Although haploid plant (a) produced many such plump pollen, not many seeds resulted. Only nine grains were obtained, as seen in Tables 3 and 4. It seems that the egg of the haploid was not good, as in  $F_1$ , although the pollen from the haploid might be somewhat more functional than that from the  $F_1$  plants.

TABLE 3. Kernels obtained from haploid *Aegilotriticum* and the  $F_1$  plant  
(*Aegilops ovata*  $\times$  *Triticum dicoccoides*)

	Pollination	Number of spikelets examined	Number of grains obtained
$F_1$ ( <i>Ae. ovata</i> $\times$ <i>T. dicoccoides</i> )*	unprotected	139	4
Haploid <i>Aegilotriticum a</i>	unprotected	67	2
	bagged	89	2
Haploid <i>Aegilotriticum b</i>	unprotected	32	0

\* Cf. KIHARA, 1929.

TABLE 4. Kernels raised from pollination between  
*Aegilotriticum* and its haploid

	Number of florets crossed	Number of grains obtained
Haploid $a \times$ diploid	68	0
Diploid $\times$ haploid $a$	80	5

### Haploids in *Triticum monococcum*<sup>(1)</sup>

As generally seen in other cases, the external appearance of these haploids was slender compared with the diploid. The spikes from diploid and haploid are shown in Fig. 45.

(1) Between haploids from the seeds of bagged spikes and from those obtained after various treatments with X-rays, no special difference could so far be observed either morphologically or karyologically, only certain fragments of chromosomes in the haploid obtained from the X-ray treatment having been observed (see Fig. 72). For this reason the writer has treated them in the same way without classifying them into two groups.



Fig. 45. Spikes from *Triticum monococcum*. Natural size.  
a, Diploid. b, Haploid.

KIHARA and KATAYAMA (1933) have reported on the meiosis of haploid *monococcum*. They paid particular attention to the structure of the chromosomes during the prophase stage, the distribution of



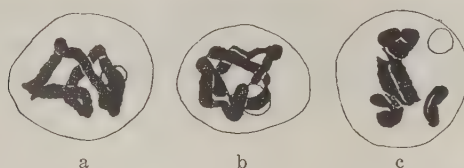
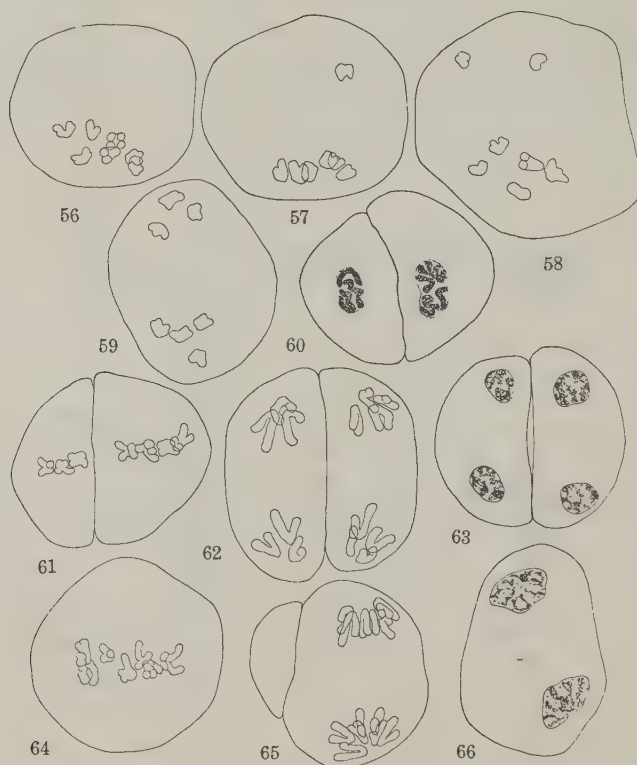


Fig. 46. Chromosomes at diakinesis in haploid *monococcum*.  $\times 2000$ . (cf. KIHARA and KATAYAMA, 1933). a, Seven univalents connected end-to-end and forming a ring. b, Two rings formed from groups of 3 and 4 univalents. c, Three rings consisting of two univalents and one unconnected univalent.



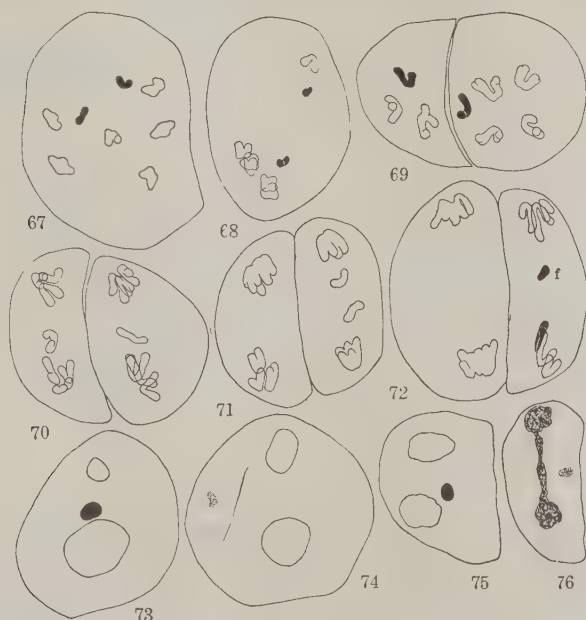
Figs. 47-55. Haploid *monococcum*. Different figures from the third contraction to the anaphase at the first division.  $\times 2000$ . 47, Third contraction. 48, Nuclear membrane has disappeared. 49, Chromosomes appear individually. The connection of univalents is shown also distinctly. 50, The connection is gradually lost. 51-52, Seven univalents separating at random to different poles. 53, Polar concentration of univalents. 54, Metaphase. 55, Anaphase.

univalent chromosomes at the metaphase being also mentioned. In this paper the writer will describe principally the chromosome movement after the first meiotic metaphase; that is, the necessary points in comparison with haploid *Aegilotricum* will be mentioned.



Figs. 56-66. Typical movement of univalents in haploid *monococcum*. Acetocarmine preparation.  $\times 1200$ . 56-60, First division. 56-59, Distribution of seven univalent chromosomes at the anaphase. 56, 0-7. 57, 1-6. 58, 2-5. 59, 3-4. 60, Interkinesis. 61-66, Second division. 61-63, Homotypic division of PMCs, whose seven univalents were distributed 3-4 at the first division. 61, Metaphase. 62, Anaphase. 63, Pollen tetrad. 64-66, Homotypic division of PMCs, whose univalents were distributed 0-7 at the first division. 64, Metaphase with seven chromosomes. 65, Anaphase. 66, Pollen dyad believed to have contained seven chromosomes in each nucleus.

In the diakinesis of the first division, the univalent chromosomes were usually connected at the end to form a ring or rings (Fig. 46). At early metaphase after the third contraction, seven univalents were distributed at opposite poles. Generally, they did not



Figs. 67-76. Unusual figures in the meiotic division of haploid *monococcum*. Acetocarmine preparation.  $\times 1200$ . 67-68, Anaphase of the first division. 67, Polar view. Six dyad chromosomes and two monads. 68, Side view. Distribution in one dyad + one monad and five dyads + one monad. 69, Polar view. Metaphase of the second division. One cell contains two dyad chromosomes and one monad. The other contains 4 dyads and one monad. 70-72, Anaphase of the second division. 70, One chromosome in each cell lagging in movement. Those chromosomes will probably be separated into a monad at the first division. 71, Two laggards occur in one of the dyad cell. 72, A chromosome in the right cell is segmented into two parts. The part of fragment (f) is lagging. This PMC was obtained from the haploid in the progeny from X-rayed spikes. 73-74 and 75-76. Telophase at the first and second divisions. 73 and 75, Micronucleus. 74, One chromosome is situated on one side and the cell plate is observed in the space between two nuclei and the chromosome. 76, Chromatin bridge and a micronucleus.

move to make an equatorial plate, but remained as they were and thus formed two daughter nuclei. In the second division, each chromosome behaved as in the usual homotypic division and produced pollen tetrads or dyads. These processes are seen in Figs. 47-55 and 56-66.



Figs. 77-82. Haploid *monococcyus*. Bipartite chromosomes and spindles. First division.  $\times 2000$ . 77-78, A bipartite chromosome. 79, A bipartite chromosome and two univalents connected at the one end (a). 80, Chromosomes orientated to the equatorial region. 81, Two spindles. 82, Somewhat curved spindle.

Against this ordinary behaviour, however, certain irregularities were sometimes noticed (Figs. 67-76 and 77-82). At times two chromosomes were connected to a bipartite (Table 5; cf. KIHARA and KATAYAMA, 1933). A univalent chromosome sometimes split at the first division and separated to different poles. (Generally univalents that had been left on the equatorial region split at the first division). Such chromosomes partook of a special movement also at the second division. This is of some interest in connection with the occurrence of bipartite chromosomes. It may perhaps be inferred either that one of the univalent chromosomes that formed the bipartite

had a duplicated segment of chromosome or that some other change had occurred.

TABLE 5. Frequency in the occurrence of bipartite chromosomes of the haploid *monococcum* at meiosis

Number of bipartite chromosomes	0	1	Total
Frequency	490	10	500

The distribution of univalents was counted at the first anaphase and at the second division, as shown in Table 6 (*cf.* KIHARA and KATAYAMA, 1933). From this Table the proportion of distribution of the second division is nearer to the theoretical random distribution obtained by expanding the binomial  $(0.5 + 0.5)^7$  than that of the first division. At the first division the distribution is excessive in the 3-1 separation—a result probably not only of the existence of bipartite chromosomes, but also of observational errors.

TABLE 6. Distribution of  $7_1$  of the haploid *monococcum* at meiosis

Distribution of univalent chromosomes	3-4	2-5	1-6	0-7	Irregular* figures	Total
Counted from the 1st anaphase	326	106	31	4	33	500
Counted from the 2nd division	26	10	4	2	8	50

\* See text.

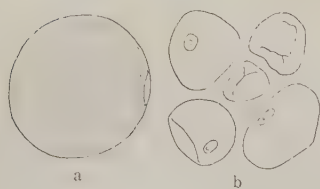


Fig. 83. Pollen grains from haploid *monococcum*.  $\times$ ca. 450.  
a, Plump. b, Contentless.

If a gamete were to contain seven chromosomes resulting from such random distribution in the first division, it would develop well and be functional. In fact, out of one thousand pollen grains tested by the writer, five were plump and the others shrunk and devoid of contents (Table 7 and Fig. 83).



TABLE 7. Plump pollen grains from diploid and haploid plants in *Triticum monococcum*

	Total number of pollen examined	Number of plump pollen	Number of empty pollen	Percent of plump pollen
Diploid	1000	980	20	98.00
Haploid	1000	5	995	0.50

The total number of PMCs for such pollen grains is assumed to be nearly 250. In two of the PMCs, division might occur theoretically with distribution 0-7 (i.e.,  $2/256=2 \cdot 2 (1+1)^7$ ). Two such PMCs will make four pollen grains resulting in dyad formation—approximately the observed number.

Seed production was tested by using unbagged spikes. The number of plants examined was 2 individuals in 1932 and also 24 individuals in 1933. Two of these individuals produced several grains, but the others did so rarely. The average result will be found in Table 8.

TABLE 8. Kernels obtained from haploid *monococcum*

Number of spikes	Number of spikelets	Number of grains
289	8285	20

If every egg cell in which the EMCs had divided with a distribution of 0-7 were to produce a grain each, we might have more than 65 grains. But on all pistils containing egg cells with seven chromosomes there would not be sufficient normal pollen for fertilization under natural conditions.

### Progenies from haploid plants

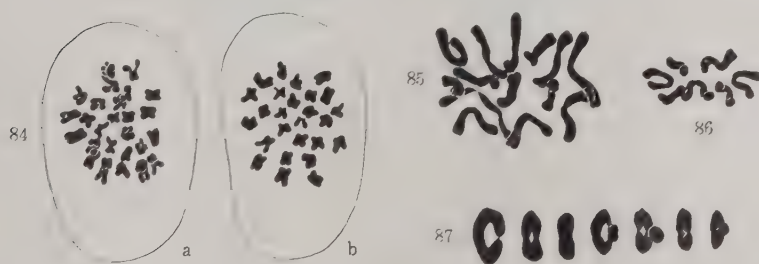
Germination of grains obtained from haploid plants was not so satisfactory, although even then the writer obtained 4 individuals in the offspring from haploid *Aegilotriticum a* and also 6 from haploid *monococcum*. The former was similar externally to octoploid *Aegilotriticum* and produced several grains. As for the latter, some of them were similar in every respect to the control diploid and the others

to the parental haploid. The chromosome number was counted on the PMC and in the *monococcum* together with the root-tip. The results are shown in Table 9.

TABLE 9. Germination of kernels obtained from haploids in *Aegilotriticum* and *Triticum monococcum*, and the number of chromosomes in the resulted individuals

	Pollination	Number of grains sown	Number of grains germinated	Number of chromosomes
Haploid <i>Aegilotriticum a</i> ( $2n = 27 + f$ )	bagged	2	1	52
	unprotected	2	1	ca. 49
	diploid $\times$ haploid	5	2	ca. $49 + f$ & 53
Haploid <i>monococcum</i> ( $2n = 7$ )	unprotected	19	6	7(3)* & 14(3)

\* The number in parentheses is that of the plants that were examined.



Figs. 84 a-b. Anaphase of the first division in the PMC of the offspring from haploid *Aegilotriticum a*. 52 dyad chromosomes in two successive sections.  $\times 1600$ .

Figs. 85-87. Metaphase chromosomes of the offspring from haploid *monococcum*. 85-86, Chromosomes from root-tip cells.  $\times 2000$ . 85, Fourteen chromosomes. 86, Seven chromosomes. 87, Seven bivalents from a PMC. Acetocarmine preparation.  $\times 1500$ .

As seen in the above table, in the offspring of haploid *Aegilotriticum a*, the number of chromosomes is lower than in those of the diploid, though it approaches the parental number (Fig. 84). In the offspring of haploid *monococcum*, however, the matured plants were diploid and haploid (Figs. 85-87 and 88).

On comparing the diploid and haploid offsprings obtained from haploid *monococcum* with the original diploid and haploid, usually no differences were observed, either karyologically or in the external characters. In the diploid offspring seven bivalents behaved regularly at meiosis. In the haploid offspring seven univalents were distributed at random at the first division, while sometimes one bipartite chromosome in a cell was also observed. The number of chiasmata

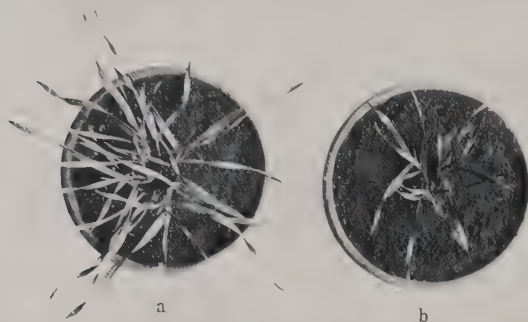


Fig. 88. Young plants raised from haploid *monococcum*. a, Diploid. b, Haploid.

at the first metaphase was counted in ten complete cells in diploid offspring from haploid as well as in the control diploid (Table 10). In this observation no special difference could be noticed between diploids derived from haploid and from the control plant, though it seemed that a somewhat larger number of total chiasmata was noticed in the former.

TABLE 10. Number of chiasmata at the first metaphase of diploid *monococcum* of different origins

	Number of bivalents	Number of chiasmata per bivalent	
		Total	Terminal
Control diploid	70	1.94	0.44
Diploid raised from haploid	70	2.00	0.40

## Discussion

### I. Movement of univalent chromosomes

A comparison was made of the movement of univalent chromosomes of haploids from *Triticum monococcum* and *Aegilotriticum* No. 3, and also of the  $F_1$  (*T. dicoccoides*  $\times$  *Aegilops ovata*). This *Aegilotriticum* originated from the offspring of the above  $F_1$  plant. The typical cases of univalent movement for each material are classified as follows:—

A. The case in which the largest number of the chromosomes are univalent.

(1) At the first division, the univalent chromosomes *do not form the nuclear plate* since they remained in the stage of polar concentration. The resultant dyad cells divide regularly homotypically at the second division. Most of the divisions in haploid *monococcum* followed this course.

(2) At the first metaphase the univalents *orientate to the equatorial region* and divide homotypically. Double splitting of univalents throughout the first and second divisions has not been observed hitherto in wheat species. These dyad cells will therefore become pollen grains. Such figures were observed usually in haploid *Aegilotriticum b*, and sometimes in the  $F_1$  plant (*cf.* KIHARA and KATAYAMA, 1931). In  $F_1$ , the chromosome of course divided variously and some of the cells that resulted from irregular division in the first were apt to form restitution nucleus at the second division.

(3) In the anaphase of the above case (2) the figures are ruptured sometimes by *regression phenomenon*. In the second division the chromosomes unreduced in number split homotypically and result in pollen dyads. Although this was sometimes observed also in  $F_1$ , most of the PMCs in haploid *Aegilotriticum a* divided throughout this course—a reason why the haploid *Aegilotriticum a* produced so many plump pollen grains.

B. The case in which many bipartite chromosomes are formed.

The bipartites (bivalent) behave in the usual manner throughout the first and second divisions, that is, bipartites separate reductionally at the first division, while the resultant dyad chromosomes split homotypically in the second. This process combines with the

respective cases in A showing the movements of univalents. These cases were usually observed in  $F_1$  plants.

(1) At the first division the univalents separate at random to different poles, while at the second homotypic splitting occurs. These however are not usually observed.

(2) Univalents orientate to the equatorial region and split homotypically at the first division. In the second, monad chromosomes separate at random to different poles. This is seen usually in *Triticum* species.

(3) Regression phenomenon occurs not only in the first division, but also in the second. From either case pollen dyads result, but the functional diploid pollen originates only when regression has occurred at the first division. Regression phenomenon is usually observed in the division of hybrid PMCs and restitution nuclei are seen in abundance under certain external conditions.

From what has just been stated, the main karyological differences in the different materials are summed up as follows:— (1) In  $F_1$  plants, various cases are seen and the univalent chromosomes usually orientate well to the equatorial region at the first division. Some bipartites are also formed. But in the haploids the behaviour of chromosomes is generally uniform and only a few bipartites, such as in haploid *Aegilotriticum a* (of course in haploid *monococcum*), are observed. (2) In haploid *a* especially, regression phenomenon occurs at the first division and results in many plump pollen grains. (3) Usually no orientation of univalents occurs in haploid *monococcum*.

Since the three materials,  $F_1$ , haploid *Aegilotriticum a*, and haploid *b*, seem to be in the homologous condition karyologically, it is interesting to consider the differences between them. Compared with  $F_1$ , haploid *Aegilotriticum a* differs considerably from it in its slender appearance, opening of anthers, and behaviour of chromosomes (*i.e.*, in the movement of univalents or in the number of bipartites). Haploid *b* shows less difference, being rather closer to  $F_1$ . That is, haploid *b* does not open its anthers, and in the other points is also closer to  $F_1$ . Consequently, the difference between haploid *a* and  $F_1$  will be arisen chiefly from the fact that in the former, a univalent lost its main part, leaving only a small portion in the fragment. It will thus be understood that the resultant pollen grains from haploid *a* are rather functionless. In addition to this cause of the



difference between  $F_1$  and haploid  $a$ , it would seem that the karyological characters shown when different genomes have combined may present a different aspect with the passage of a number of generations after the occurrence of the combination.

We shall next discuss the cause of the difference in the orientation of univalents to the equatorial region between haploid *Aegilotriticum* or  $F_1$  and haploid *monococcum*. In  $F_1$  plants having several different genomes, the chromosomes usually orientate to the equatorial region at the first division, and so do the chromosomes in haploid *Aegilotriticum*. But in haploid *monococcum*, which has only a single genome as its nuclear content, the univalent chromosomes do not usually orientate, the seven univalents distributed at random at the early metaphase remaining stationary in polar concentration.

In the orientation of univalent chromosomes, similar cases may be seen in other haploid examples. In the usual figures of haploid from diploid species, the univalent chromosomes at the first metaphase generally do not orientate to the equatorial region, e.g., *Datura Stramonium* (BELLING and BLAKESLEE, 1923, 1927), *Nicotiana glutinosa* (GOODSPEED and AVERY, 1929), *N. Langsdorffii* (KOSTOFF, 1929), *Solanum lycopersicum* (LINDSTROM, 1929; LINDSTROM and KOOS, 1931; HUMPHREY, 1934), *Crepis capillaris* (HOLLINGSHEAD, 1930), *Pharbitis Nil* (U, 1932), *Oryza sativa* (MORINAGA and FUKUSHIMA, 1932, 1934; NAKAMURA, 1933), *Portulaca grandiflora* (OKURA, 1933). In certain special cases of course univalents do orientate to the equatorial region, as in *Matthiola incana* (LESLEY and FROST, 1928). In haploids from allopolyploid, the univalents are usually orientated to the equatorial region, cf. *Nicotiana Tabacum* (CLAUSEN and MANN, 1924; CLAUSEN and LAMMERTS, 1929; McCRAV, 1932), *Triticum compactum* (GAINES and AASE, 1926) and *Brassica Napella* (MORINAGA and FUKUSHIMA, 1933). In haploids occurring from autopolyploids, (e.g., *Oenothera Lamarckiana gigas*, HÅKANSSON, 1926; *Oe. biennis gigas*, STOMPS, 1928), the behaviour of their chromosomes need not be considered here since they are not haploids karyologically. When haploids arise from autoallopolyploids, as in *Solanum nigrum* (JØRGENSEN, 1928), the behaviour is complicated, combining that of univalents and bivalents.

Since, as mentioned above, we have seen various cases of movements of univalents in different species or figures, we naturally conclude that the movement is conditioned by three factors —chromosomes, cytoplasm, and environment.

## II. End-to-end connection of univalent chromosomes

If an affinity is present among the different genomes in haploids from allopolyploid plants, bipartite chromosomes sometimes occur as is seen in haploid *Brassica Napella* (MORINAGA and FUKUSHIMA, 1933). This corresponds to  $F_1$  hybrids of two different genotypical species as in certain cases of *Aegilops*  $\times$  *Triticum*, where the number of bipartite chromosomes is influenced by environmental conditions (KIHARA, 1929; KATAYAMA, 1931). In the haploid from diploid species, however, the component chromosomes usually have no homologous parts, so that no bipartites are seen as a rule, e.g., *Datura Stramonium* (BELLING and BLAKESLEE, 1923, 1927), *Nicotiana glutinosa* (GOODSPEED and AVERY, 1929), *N. Langsdorffii* (KOSTOFF, 1929), *Solanum lycopersicum* (LINDSTROM, 1929; LINDSTROM and KOOS, 1931; HUMPHREY, 1934), *Crepis capillaris* (HOLLINGSHEAD, 1930), *Pharbitis Nil* (U, 1932), and *Portulaca grandiflora* (OKURA, 1933). But in the latter, some bipartites are found at times, as in *Oenothera franciscana* (EMERSON, 1929; BLEIER, 1933), *Oe. blanda* (CATCHESIDE, 1932), *Oe. Hookeri* (BLEIER, 1933) and *Oryza sativa* (MORINAGA and FUKUSHIMA, 1934). This occurrence is explained by some investigators, (e.g., CATCHESIDE, 1932) by duplication of homologous segments of chromosomes.

KIHARA and KATAYAMA (1933) have also observed at times a bipartite chromosome in PMC of haploid *monococcum*. In this plant seven univalent chromosomes are connected end-to-end at diakinesis in their various numbers. This connection is observable up to early metaphase, while in the true metaphase only one bipartite chromosome is usually seen.

Two types are therefore seen in the connection of chromosomes in haploid *monococcum*. One is that in which the connection is continued to the metaphase as a bipartite and the chromosomes divide and go to different poles. In the other case, the connection is lost already at the metaphase. In somewhat early metaphase such connected chromosomes may still be observed together at the same pole, while the bipartite orientates to the equatorial region. This connection is like that observable also in  $F_1$  hybrids (*T. dicoccoides*  $\times$  *Ae. ovata*) or in haploid *Aegilotricum* at diakinesis or at a somewhat later stage.

The former connection tends to confirm the existence of homologous parts in chromosomes. The latter connection probably occurs

from terminal affinity (cf. KIHARA et al. 1931; DARLINGTON, 1932), it being considered that such connections are usually apt to occur when there are no homologous chromosomes. This relation however must be established by further study.

### III. Doubling and reduction in the number of chromosomes

The  $F_1$  plant from two species having different chromosomal contents (e.g., *Ae. ovata*=CCEE and *T. dicoccoides*=AABB) is a haploid (ABCE) genomically. Sometimes such  $F_1$  plants produce a certain number of grains, while a fertile constant individual occurs in plants from such grains, in which case all the different chromosomes that were in the  $F_1$  plant would be doubled (e.g., *Aegilotriticum*=AABBCCEE). In earlier generations following this synthesis, the new constant species will still remain unstable in their chromosomal or physiological condition. Occasionally, such new species may produce certain haploid plants and some other chromosomal or genic variants in its offspring.

In the natural constant species, the potency for parthenogenetic development in egg cells varies also in different species. In *T. monococcum*, occasionally the eggs are able to effect a parthenogenetic development (cf. KATAYAMA, 1933, 1934 a-b).

Some individuals obtained from haploid plants become again fertile constant (the original diploid condition) or they are sometimes haploid. In the former the resultant plant should have chromosomes of double number as mentioned in connection with the  $F_1$  hybrid. These processes generally obtain in the diploid species; that is, the matured offspring from haploid *monococcum* became diploid or haploid. In other examples of haploids from diploid species such instances are also observed, as in *Oenothera franciscana* (DAVIS and KULKARNI, 1930; LELIVELD, 1932), *Solanum lycopersicum* (LINDSTROM and KOOS, 1931), *Oc. blandina* (CATCHESIDE, 1932), etc.<sup>(1)</sup> But, in the polyploid species some of the genoms have incomplete chromosomal contents, and still the individual sometimes survives. That is, although the number of chromosomes in pollen grains from

(1) It is also reported that some diploid branches are formed on the haploid plant of *Crepis capillaris* (HOLLINGSHEAD, 1930) or *Oryza sativa* (MORINAGA and FUKUSHIMA, 1934). In these instances the doubling of chromosomes has arisen somatically.

haploid *Aegilotriticum* approaches the unreduced number, some of chromosomes would be eliminated. These pollen grains were still fairly plump with contents. In the resultant offspring, the number of chromosomes nearly approached that of the parental octoploid, but a considerable number was lost.

As mentioned above, individuals cannot survive in chromosomes of lower number than monoploid. If an incomplete genom joins the complete ones, a certain combination results in the survival of individuals. Generally, it will be most desirable for the existence of individuals that in the doubling and reduction of chromosomes a single genom is taken as unit.

This remark concerning progenies from haploids is supported by general haploid examples. That is, haploids from allopolyploid species are not only in exact haploid condition in each genom, but they sometimes have additional chromosomes or lose some from certain genoms. However, in the haploids from diploid species, no chromosome is ever lost from the genom, though certain chromosomes are added to the genom. From this view-point, the writer has classified (though provisionally) the haploid plants as follows: the haploid from diploid species (or basal species) is called a *monohaploid*. If the haploid had occurred from allopolyploids, it is classified under the name of *polyhaploid*. If the different genoms are complete in their components, such haploids we call *euhaploids*. When, on the contrary, certain chromosomes or their fragments in some genoms are duplicated (*hyper*) or eliminated (*hypo*), we call them *heterohaploids*. Haploids from autoallopolyploids (or autopolyploids) should be called *pseudohaploids*. In these examples of haploids, we must carefully bear in mind the fact that theoretically no monohaploid will ever be found in hypohaploids. These relations are shown in Table 11 with certain examples so far reported.

TABLE 11. Classification of haploid plants\*

	Monohaploid	Polyhaploid		
	A	AB	ABC	ABCD
Euhaploid	<i>Datura Stramonium</i> (2n = 12). BLAKESLEE et al. 1922. BELLING & BLAKESLEE, 1923, 1927. <i>Crepis capillaris</i> (2n = 3). HOLLINGSHEAD, 1928, 1930.	<i>Nicotiana Tabacum</i> (2n = 24). CLAUSEN & MANN, 1924. CHIPMAN & GOODSPEED, 1927. RUTTLE, 1928.	<i>Triticum</i> <i>compactum</i> (2n = 21). GAINES & AASE, 1926.	<i>Aegilotriticum</i> <i>forma</i> <i>fertilis</i> No. 3 (2n = 28). The writer.

\* In this Table A, B, and C show different genoms, while x shows some chromosomal component either as chromosomes or their fragments, both in various numbers.

TABLE 11. (Continued)

	Monohaploid	Polyhaploid		
Euhaploid	A	AB	ABC	ABCD
	<i>Solanum lycopersicum</i> (2n = 12). LINDSTROM, 1929. LINDSTROM & KOOS, 1931. HUMPHREY, 1934. <i>Nicotiana glutinosa</i> (2n = 12). GOODSPEED & AVERY, 1929. <i>N. Langsdorffii</i> (2n = 9). KOSTOFF, 1929. <i>Oenothera franciscana</i> (2n = 7). EMERSON, 1929. DAVIS & KULKARNI, 1930. STOMPS, 1930 a, 1931. BLEIER, 1933. <i>Oe. Hookeri</i> (2n = 7). STOMPS, 1930 a. BLEIER, 1933. <i>Oe. argillicola</i> (2n = 7). STOMPS, 1930 b. <i>Oe. rubricalyx</i> (2n = 7). GATES & GOODWIN, 1930. <i>Oe. blandina</i> (2n = 7). CATCHESIDE, 1932. <i>Pharbitis Nil</i> (2n = 15). U, 1930, 1932. <i>Oryza sativa</i> (2n = 12). MORINAGA & FUKUSHIMA, 1931, 1932, 1934. NAKAMURA, 1933. <i>Triticum monococcum</i> (2n = 7). KIHARA & KATAYAMA, 1932, 1933. CHIZAKI, 1933. KATAYAMA, 1934 a-b. The writer. <i>Zea Mays</i> (2n = 10). RANDOLPH, 1932. <i>Portulaca grandiflora</i> (2n = 9). OKURA, 1933.	CLAUSEN & LAMMERTS, 1929. CHRISTOV, 1929/ 1930. McCRAY, 1932. <i>Digitalis</i> <i>mertonensis</i> (2n = 56).** BUXTON & DARLINGTON, 1932. <i>Brassica Napella</i> (2n = 19). MORINAGA & FUKUSHIMA, 1933.	<i>T. vulgare</i> (2n = 21). YAMASAKI, 1934.	
Hetero- haploid	A + x	AB ± x	ABC ± x	ABCD ± x
	<i>Matthiola incana</i> (2n = 7 + f). LESLEY & FROST, 1928.			<i>Aegilotriticum</i> forma <i>fer-</i> <i>tilis</i> No. 3 (2n = 28-f) The writer.
Pseudohaploid	AA***	AAB	AABC	AABCD
	<i>Oenothera Lamarckiana</i> <i>gigas</i> (2n = 14). HÅKANSSON, 1926. <i>Oe. biennis gigas</i> (2n = 14). STOMPS, 1928.	<i>Solanum nigrum</i> (2n = 36). JØRGENSEN, 1928. <i>Nicotiana rustica-</i> <i>paniculata</i> (2n = 36). LAMMERTS, 1932.		

\*\* This species is recorded only provisionally in this column.

\*\*\* Similar examples of diploids, that probably occurred parthenogenetically from autotetraploids, are usually seen in the crosses between diploids and tetraploids, e.g., *Datura Stramonium* (BLAKESLEE, BELLING and FARNHAM, 1923), *Campanula persicifolia* (GAIRDNER, 1926; GAIRDNER and DARLINGTON, 1931) and etc.



#### IV. Considerations on the use of haploid plants for karyogenetic studies

In studying univalent behaviour, the haploid plant as well as hybrid plants are indispensable. Comparative studies, especially in the prophases of diploid and haploid plants, should contribute to the solution of some karyological problems. However, only a few points on the formation of polyploid plants regarding the writer's observation will be mentioned here.

(1) No plant has so far been found having a lower number of chromosomes than the monohaploids. It shows that a genom carries the minimum number of genes which is necessary for organic existence (*cf.* KIHARA and LILIENFELD, 1932, etc.).

(2) If a haploid plant should occur in a polyploid species, the polyhaploid may tell us whether the parental species originated autopolyploidically or allopolyploidically, as seen in *Solanum nigrum* (JØRGENSEN, 1928) and other pseudohaploids. By examining the haploid derived from the allopolyploid, it is also possible to know the affinity between two different genomes, *e.g.*, *Brassica Napella* (MORINAGA and FUKUSHIMA, 1933) and other polyhaploids.

(3) In the haploid plant, we may be able to observe sometimes karyological changes so slight as to be impossible of observation in the diploid (*cf.* EMERSON, 1929; KIHARA and KATAYAMA, 1933).

(4) By the doubling of the number of chromosomes, generatively or somatically, it is possible sometimes to obtain true homozygous individuals in the offspring from haploids, *e.g.*, *Solanum lycopersicum* (LINDSTROM and KOOS, 1931), *Oryza sativa* (MORINAGA and FUKUSHIMA, 1934), etc.

Special reference to the relation between parthenogenesis and the formation of homozygous plants in connection with practical work in breeding has already been made by EAST (1930) and TERAOKA (1934). In the usual crosses between two agronomical varieties, various eggs are expected as the result of segregation in  $F_1$  plants. If parthenogenesis occurs in these eggs and the doubling of chromosomes occurs pathozygotically, various new types of homozygous individuals will be obtained in the  $F_2$  descendants.

(5) It may also be said that chromosomal and genic variants are apt to obtain in the offspring from haploids, *cf.*, *Datura Stramonium* (BLAKESLEE et al. 1927), *Oenothera franciscana* (DAVIS and KULKARNI, 1930; ANDERSON, 1933), etc.

(6) The haploid plant (AB) from allopolyploids (AABB) may, after random segregation of chromosomes, result sometimes in different diploid species (AA or BB), whence it may be expected that an ancestral species that has perished may occur again through the process mentioned.

### Summary

In this study two different haploids from *Aegilotriticum* and *Triticum monococcum* are compared karyologically. Two chromosomally different individuals ( $2n=28$  and  $2n=27+f$ ) were contained in haploid *Aegilotriticum*, and both of them were obtained from *Aegilotriticum forma fertilis* No. 3 ( $2n=56$ ). Since the above mentioned *Aegilotriticum* has occurred by the doubling of the number of chromosomes in  $F_1$  hybrids ( $2n=28$ ) between *T. dicoccoides* and *Aegilops ovata*, this  $F_1$  plant was investigated also in relation to haploid *Aegilotriticum*.

The result of the observation showed certain differences depending upon the materials as follows:— (1) Behaviour of univalent chromosomes, (2) Sterility of pollen grains and (3) The rate of increase in chromosome number in the offspring.

These differences are considered in connection with the number of chromosomes. That is, the movement and connection of univalents are discussed as well as doubling and reduction in the number of chromosomes. The use of haploid plants for karyogenetic studies is also mentioned.

The writer wishes to acknowledge his indebtedness to Prof. K. MIYAKE for his kind advices and criticisms in this work. The material for the present study was obtained chiefly at the Laboratory of Genetics of the Kyoto Imperial University, while certain studies with this material have been published already in collaboration with Prof. H. KIHARA, to whom the writer wishes to express his sincere thanks.

BOTANICAL INSTITUTE, COLLEGE OF AGRICULTURE,  
TOKYO IMPERIAL UNIVERSITY.  
August, 1934.

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# Weitere Untersuchungen über die pentaploiden *Triticum*-Bastarde IV<sup>(1)</sup>

Von H. KIHARA und Sh. WAKAKUWA

Hierzu 3 Tetabbildungen

(Eingegangen am 18. Dezember 1934)

## Einleitung

Die in der III. Mitteilung (Japan. Journ. Bot. 6, 1933) besprochenen Aequationskreuzungen stellten sich ganz verschieden dar, je nachdem ob das hexa- oder das tetraploide Elter den Pollen zu der Rückkreuzung geliefert hatte. Im ersteren Falle waren die hochchromosomigen Eizellen, im letzteren diejenigen mit den niedrigen Chromosomenzahlen die am häufigsten befruchteten. Der Unterschied trat bei dem Bastard *vulgare*  $\times$  *durum* besonders scharf hervor (Tab. 1).

TABELLE 1 (aus der III. Mitt.)

Häufigkeit der verschiedenchromosomigen Eizellen der pentaploiden Bastarde

Chromosomenzahl	14	15	16	17	18	19	20	21	Summe
$F_1 \times spelta$	2	0	1	5	13	16	4	1	42
$F_1 \times polonicum$	7	2	12	8	3	3	0	2	37
$F_1 \times vulgare$	4	3	2	6	9	5	2	0	31
$F_1 \times durum$	37	16	15	4	1	3	1	4	81

Zur Erklärung dieses auffallenden Unterschiedes haben wir folgende zwei Möglichkeiten in Betracht gezogen: 1. Selektive Befruchtung der 18–21-chromosomigen bzw. 14–17-chromosomigen Eizellen im Rückkreuzungsversuch  $F_1 \times$  Dinkel bzw.  $F_1 \times$  Emmer

(1) Contributions from the Laboratory of Genetics, Biological Institute, Kyoto Imperial University. No. 55.

und 2. Elimination der aus der Verbindung von 14–17-chromosomigen Eizellen mit 21-chromosomigen Spermakernen gebildeten Zygoten bei  $F_1 \times$  Dinkel infolge von mangelhafter Keimung.

TABELLE 2 (aus der III. Mitt.)  
Kreuzungserfolg bei den Aequationskreuzungen

Kreuzung	Zahl d. bestäubten Blütchen	Zahl d. Körner (%)	ausgesät	gekeimt (%)	Erfolg %
$F_1 \times spelta$	252	120(47,6)	120	48(40,0)	19,0
$F_1 \times polonicum$	276	64(23,2)	64	41(64,1)	14,9
$F_1 \times vulgare$	370	191(51,6)	190	65(34,2)	17,7
$F_1 \times durum$	492	254(51,6)	253	187(73,9)	38,2

Die damaligen Versuche wiesen einen ziemlich niedrigen Kreuzungserfolg auf (Tab. 2). War unsere Annahme richtig, dann müsste der auffallende Unterschied bei Erzielung eines möglichst guten Kreuzungserfolges ganz oder teilweise verschwinden. Die Ergebnisse eines derartigen Versuches, bei dem sowohl auf das Gelingen der einzelnen Bestäubungen als auch auf Keimung und Aufzucht der Keimlinge ganz besondere Sorgfalt gelegt wurde, sollen im folgenden mitgeteilt werden.

### Rückkreuzung des pentaploiden Bastards *T. polonicum* $\times T. spelta$ mit *T. spelta* und *T. polonicum*

Wie aus Tab. 3 zu ersehen ist, ist es uns tatsächlich gelungen,

TABELLE 3  
Kreuzungserfolg bei der Aequationskreuzung (*T. polonicum*  
 $\times T. spelta$ )  $\times T. spelta$  und *T. polonicum*

Kreuzung	Zahl d. bestäubten Blütchen	Zahl d. Körner	ausgesät	gekeimt	(von d. Keiml. eingegangen)	Erfolg in %
$F_1 \times T. spelta$	304	267	267	251	(18)	82,5
$F_1 \times T. polon.$	300	256	256	253	( 0)	84,0

einen sehr hohen Kreuzungserfolg zu erzielen. Bei der Verbindung mit *T. spelta* war, wie erwartet (vgl. III. Mitt.), die Keimung etwas schlechter und die Lebensfähigkeit der Keimlinge merklich geringer (18 gingen ein). Bei sämtlichen am Leben gebliebenen Pflanzen (ausser einer) wurden die Chromosomenzahlen in den Wurzelspitzen festgestellt. Die Resultate sind aus Tab. 4 und der graphischen Darstellung in Abb. 1 a und b zu ersehen.

TABELLE 4

Häufigkeit der verschiedenchr. Eizellen des pentaploiden Bastards *T. polonicum*  $\times$  *spelta* auf Grund der Aequationsversuche  $F_1 \times T. spelta$  u.  $F_1 \times T. polonicum$

Verbindung	Chromosomenzahlen								Summe
	14	15	16	17	18	19	20	21	
$F_1 \times spelta$	17	33	50	51	43	31	6	1	232
$F_1 \times polonicum$	17	35	47	48	44	35	19	5	250

Die Variationsreihen stellen sich in beiden Aequationsversuchen ganz ähnlich dar; von dem in den früheren Versuchen so auffallenden Unterschied ist hier nichts zu bemerken. Nur das Zahlenverhältnis der 14- zu den 21-chromosomigen Eizellen ist in den beiden Rückkreuzungen deutlich verschieden, doch dürfte die Differenz rein zufällig sein (vgl. Tab. 1).

Aus der Zusammenfassung der beiden Aequationskreuzungen ergibt sich die folgende Tabelle 5.

TABELLE 5

Häufigkeit der verschiedenchr. Eizellen des pentaploiden Bastards *T. polonicum*  $\times$  *spelta* auf Grund der Rückkreuzungen zu beiden Eltern

Chromosomenzahlen	14	15	16	17	18	19	20	21	Summe
Beobachtet	34	68	97	99	87	66	25	6	482
%	7,05	14,11	20,13	20,54	18,05	13,69	5,19	1,24	100
Berechnet $\left\{ \begin{array}{l} (0,6+0,4)^7 \\ (0,7+0,3)^7 \end{array} \right.$	2,80	13,07	26,13	29,03	19,35	7,74	1,72	0,16	100
nach	8,23	24,71	31,77	22,69	9,72	2,50	0,36	0,02	100

Aus dem Vergleich der theoretischen Zahlen mit den beobachteten ergibt sich fraglos, dass die Verteilung der 7 Dinkelchromosomen nicht rein zufallsmässig sein kann. Die Häufigkeit der 14-chromosomigen Eizellen stimmt ziemlich gut mit der Verteilung nach der

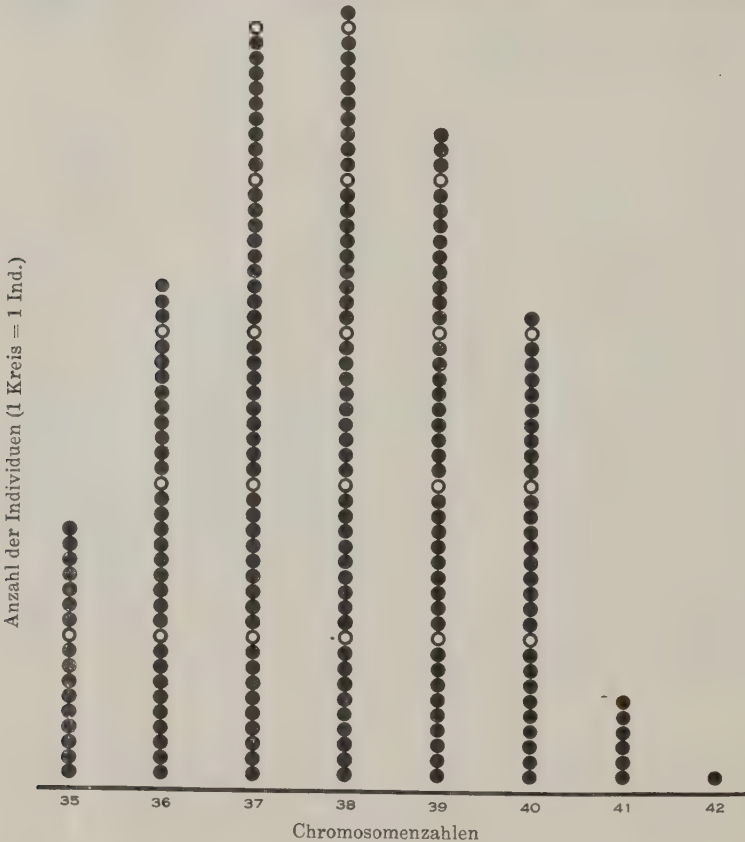


Abb. 1 a.  $F_1 \times T. spelta$

Formel  $(0,7+0,3)^7$ , aber nicht die der 21-chromosomigen, die viel zu zahlreich sind: während das aus dieser Formel abgeleitete Zahlenverhältnis 376 14-chr. : 1 21-chr. ist, wurden im Versuch 34 14-chromosomige Eizellen auf 6 21-chromosomige gefunden. Auch sind die Variationspolygone, worauf bereits in der III. Mitt. hingewiesen

wurde, sehr flach. Während das theoretische Verhältnis der 16- zu den 21-chromosomigen Eizellen 1452 : 1 ist, beträgt das gefundene 97 : 6. Es müssen also tatsächlich die Univalenten gruppenweise, d.h. mehrere zusammen, nach den Polen transportiert werden, wie wir in der erwähnten Mitteilung angenommen haben.

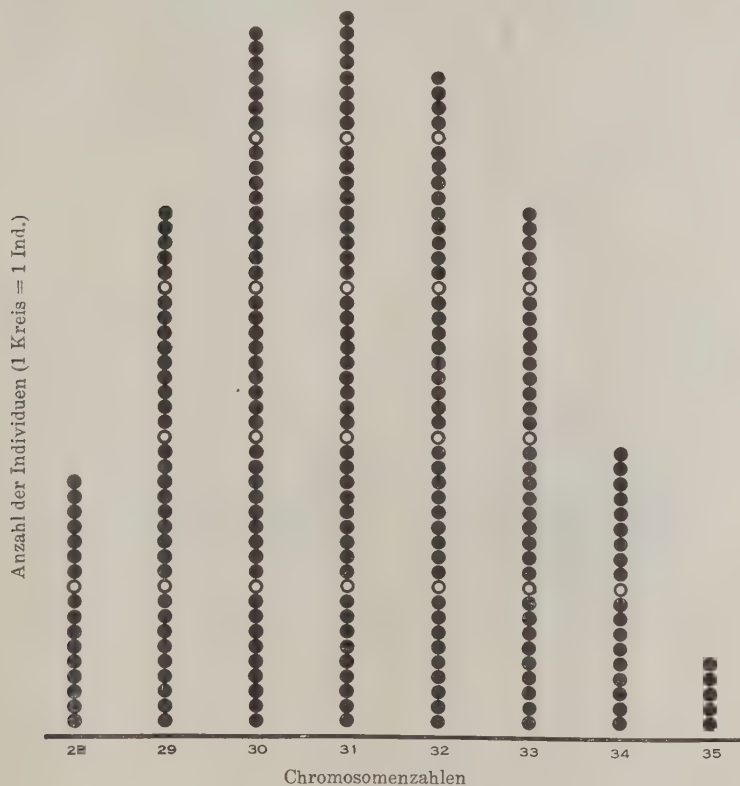


Abb. 1 b.  $F_1 \times T. polonicum$

Aus den obigen Kreuzungsversuchen geht hervor, dass 1. die Differenzen zwischen den beiden Aequationskreuzungen sich bei optimalem Kreuzungserfolg ausgleichen und 2. die sehr auffallenden Abweichungen der gefundenen Variationsreihen der verschieden-



chromosomigen Eizellen von der theoretischen sich nur durch eine von der zufallsmässigen abweichende Verteilung der 7 ungepaarten Dinkelchromosomen erklären lassen.

Es sei noch erwähnt, dass wir in den oben besprochenen Versuchen drei Pflanzen mit unerwarteten Chromosomenzahlen gefunden haben, nämlich bei  $F_1 \times T. spelta$  eine mit 32, und bei  $F_1 \times T. polonicum$  zwei mit 38 bzw. 48 Chromosomen. Für die Entstehungsweise der zwei ersten haben wir vorläufig keine Erklärung; die 48-chromosomige Pflanze könnte durch die Verschmelzung einer unreduzierten Eizelle mit fast vollständiger Chromosomengarnitur des pentaploiden Bastards (34 Chromosomen) mit einem 14-chromosomigen Spermakern entstanden sein.

### Morphologie der Pollenkörner der pentaploiden Bastarde

Frische Pollen wurden auf einen Objektträger gebracht und mit Acetokarmin gefärbt. Bei dieser Behandlung trat der innere Bau der Pollenkörner sehr deutlich zutage. Die meisten Körner enthielten

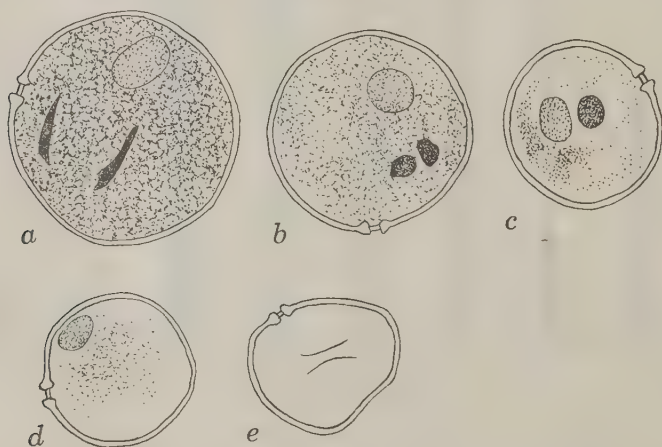


Abb. 2 a-e.  $F_1$ -Bastard *T. spelta*  $\times$  *T. polonicum*. Pollenkörner

einen runden vegetativen und zwei stets zusammen liegende spindel-förmige Spermakerne (Abb. 2a). Zwischen solchen Pollekörnern und denen der reinen Art *T. spelta* konnte kein morphologischer

Unterschied festgestellt werden. Ausserdem konnten bei dem Bastard zu einem unbeträchtlichen Teile (ca. 10%) in verschiedenem Grade mangelhaft entwickelte Körner beobachtet werden, nämlich fast normale (Abb. 2b) mit runden Spermakernen, zweikernige (Abb. 2c), einkernige (Abb. 2d) und vollkommen degenerierte (Abb. 2e). Bei *T. spelta* konnten ausser den normalen Körnern nur die zwei ersten Kategorien hier und da beobachtet werden, wie aus Tab. 6 zu ersehen ist.

TABELLE 6

Häufigkeit der verschiedenen Pollenkategorien bei dem Bastard  
*T. spelta* × *T. polonicum* u. rez. und bei *T. spelta*

	normal	fast normal	zweikernig	einkernig	deg.	Summe
<i>T. polon.</i> × <i>spelta</i>	1338	48	34	32	25	1477
rez.	1013	26	31	25	18	1113
<i>T. spelta</i>	715	4	3	0	0	722

Die untersuchte pentaploide Verbindung besitzt demnach überwiegend (90%) unter dem Mikroskop normal aussehende Pollenkörner. Sie können aber nicht alle gleich funktionsfähig sein, wie aus den Zertationskreuzungen (vgl. III. Mitt.) hervorgeht.

### Literatur

KIHARA, H., WAKAKUWA, SH. und YAMAMOTO, Y. (1933): Weitere Untersuchungen über die pentaploiden *Triticum*-Bastarde. III. Japan. Journ. Bot. 6.



# Genome-analysis in *Brassica* with special reference to the experimental formation of *B. napus* and peculiar mode of fertilization

By Nagaharu U

Kônosu farm of the Imperial Agricultural  
Experiment Station.

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With 12 tables, 35 text-figures, and plate V

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## I. Introduction

Recently the formation of the new constant polyploid species by means of the species hybridization has often been reported. On the other hand, such works coupled with those of genome-analysis, have proved that some of the existing species are really allopolyploids

which have resulted from the hybridization of two or more different species and which came to fertility and constancy by the subsequent doubling of chromosomes, as will be seen in *Aesculus carnea* (SKOVSTED, 1929, cf. DARLINGTON), *Galeopsis Tetrahit* (MÜNTZING, 1932), *Phleum pratense* (GREROR and SANSOME, 1930), and *Spartina Townsendii* (HUSKINS, 1930, cf. DARLINGTON).

During the past ten years attempts have also been made by several investigators to analyse karyo-genetically the intricate species relationships in the genus *Brassica* which includes more than 13 taxonomic species with diverse haploid numbers of chromosomes, viz. 8, 9, 10, 17, 18, and 19. Numerically the three species with higher chromosome numbers, i.e. with 17, 18, and 19, are supposed to be the allotetraploids whose genomes are composed of two of those found in the three species with the lower chromosome numbers, viz. 8, 9, and 10. In fact the works of MORINAGA, SASAOKA, and others who have succeeded in several interspecific crosses in the genus show that the genomes of the named three species are obviously the composite ones; the 17-chromosomal species is proved to have a set of 9 chromosomes which is identical with the haploid set of 9-chromosomal species and each of the 18- and the 19-chromosomal species, to have a set of 10 chromosomes identical with the haploid set common to the 10-chromosomal species. The complete analysis of these, however, have not yet been performed and in each case the remaining unknown set or sets of chromosomes which constitute these composite genomes together with the sets above described are not proved to be the definite ones.

Since 1929 the breeding work on a number of species and varieties of *Brassica* has been in progress at Kōnosu farm of the Imperial Agricultural Experiment Station. Besides many intra-specific crosses, inter-specific hybridizations have been made extensively, for obtaining partly a desirable variety by the interchange of genes, and partly a new constant polyploid species of promising traits by combining different genomes in duplicated state. The present paper concerns chiefly the karyological facts observed in several of the  $F_1$  hybrids obtained, which may serve as the necessary basis of elucidation of the origin of the composite genomes in the higher-numbered species in *Brassica* which remained hitherto unexplained. Further, some remarkable phenomena caused by the anomalies at the time of fertilization including the artificial formation of *B. napus* are also dealt with.



The experiment has been carried out always under the cordial guidance of Dr. H. ANDO, Chief of the Imperial Agricultural Experiment Station, and Dr. H. TERA0, Chief of the Division of Plant-breeding and Agronomy, to whom the author is greatly indebted. He also wishes to express his sincere thanks to Prof. T. MORINAGA of the Kyûsyû Imperial University for helpful advises. Further thanks are due to my collaborators, T. NAGAMATU and U. MIDUSIMA, and many others who aided the writer in raising  $F_1$  hybrids and executing the cytological work during the course of this experiment.

## II. Material and methods

The following species and varieties were used in the experiment:

*Brassica nigra* KOCH (n=8)

*B. oleracea* L. (n=9)

var. *gemifera* ZENKER ..... "Komoti-Kanran"

var. *acephala* DC. .... "Habotan"

var. *capitata* L. .... "Sadaya-Kanran"

*B. campestris* L. (n=10)

"Enuma-Zairai"

"Hokkai"

"Yokkaiti-Marubasyu"

"Tyamogarasi"

"Yasu-Zairai"

"Naniwa-Syu"

"Kin-Natane"

"Aburakake-Syusi"

"Isobe-Zairai"

"Kasima-Zairai"

"Mie-Zairai"

*B. chinensis* L. (n=10)

"Zyun'an-Hakusai"

*B. carinata* BRAUN (n=17)

var. *Harron*

var. *cadisabeba*

*B. juncea* COSS. (n=18)

"Kigarasi"

*B. napus* L. (n=19)

var. *oleifera* DC.

"Aduma"

"Yokkaiti-Kurodane"

"Mutumi-Bansei"

"Hokkaidô-Syu"

"Ensyû-Kurodane"

"Wase-Tyôsen"

"Huzi-Syu"



Fig. 1. *B. nigra* KOCH ( $n = 8$ )

occurs a species determined by NAKAI as *B. napella* which externally resembles *B. napus* very closely, and yet is characterized by having 19 chromosomes as its gametic number. This species, he remarks, has been introduced to Japan proper comparatively recently and nothing is known about its origin, though its close resemblance to *Napus* suggests strongly its origin from the latter. NAGAI and SASAOKA (1930) in their extensive study on the chromosome number of *Brassica* species have reported that the gametic number found in the varieties of *B. napus* is obviously 19 which is quite the same as that found in *B. napella*, and have suggested on this ground that the latter might be the synonym of the former. The materials

with reference to their chromosome number. The named species has first been reported by KARPECHENKO (1922) to have 18 chromosomes as its reduced number, which has been supported hitherto by the European authors, such as DAVEY, and FRANDSEN and WINGE. Recently it has been, however, reported by MORINAGA that there



Fig. 2. *B. oleracea* L. var. *gemifera* ZENKER ( $n = 9$ ), "Komoti-Kanran."

investigated by them have comprised those presented by KARPECHENKO as well as those from European countries and U.S.A. Our karyological investigation confirms the observation of the above two authors. All the *napus* varieties cultivated in the breeding yard at Kônosu that have been collected from various countries in European continent, viz. U.S.S.R., Poland, Germany,



Fig. 3. *B. campestris* L. ( $n = 10$ ),  
"Enuma-Zairai."



Fig. 4. *B. carinata* BRAUN var. *Harron*  
( $n = 17$ ).

Rumania, Austria, and France, present exactly 19 paired chromosomes in the heterotypic metaphase of the microsporogenesis, and 38 somatic ones in the nuclear plate of root-tip cell division. Hence, it may be concluded with no doubt that the reduced number of chromosomes of *B. napus* is 19. The species *napella* should, therefore, be considered as a variety of *napus*, the detailed explanation of which has already been given by MORINAGA (1934).

Our cross operations were performed in a greenhouse between potted individuals and always the method of bud-pollination was applied.

The somatic number of chromosomes in the hybrid plants obtained as well as in their parents was examined in their root-tip cells when they were in the rosette stage. The newly developed roots at about three days after their transplantation were fixed with BENDA's or NAWASHIN's fixative, either of which has given good results. In fixing the flower buds for the investigation of the meiotic division several combinations of reagents were applied, of which BOUIN's fluid or ALLEN's modification of it proved always to be the



Fig. 5. *B. juncea* Coss. ( $n = 18$ ), "Kigarsi."

best one, the shrinkage of the cytoplasm and the clumping of the chromosomes caused by it being very slight. The paraffin sections of 12 microns were made and HEIDENHAIN's iron-alum haematoxylin was used in staining. On examining tetrads and pollen grains BELLING's iron-aceto-carmin method was frequently applied; some clear views of pollen mother cell division were obtained by this method.



Fig. 6. *B. napus* L. var. *oleifera* DC.  
(n = 19), "Aduma."



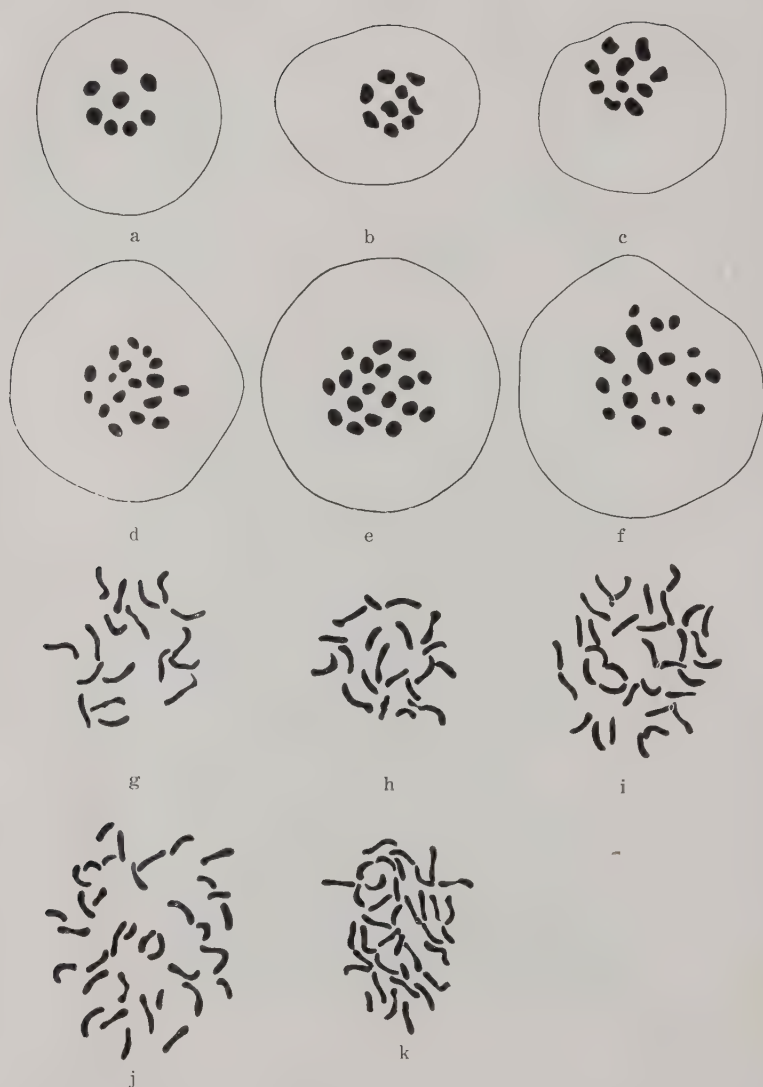


Fig. 7. Meiotic and somatic metaphases in the parental species\* (ca.  $\times 2000$ ). a-f, polar views of heterotypic metaphase in the microsporogenesis. a, *B. nigra* ( $n=8$ ). b, *B. oleracea* ( $n=9$ ). c, *B. campestris* ( $n=10$ ). d, *B. carinata* ( $n=17$ ). e, *B. juncea* ( $n=18$ ). f, *B. napus* ( $n=19$ ). g-k, polar views of somatic metaphase in the root-tip cell division. g, *B. oleracea*. h, *B. campestris*. i, *B. carinata*. j, *B. juncea*. k, *B. napus*.

### III. Results and discussion

The hybridization experiments to be reported here comprise 7 crosses which are given in the following tables showing detailed numerical data in each case respectively.

As seen in the table, varying degrees of interspecific incompatibility were noted in each cross. In many cases the cross resulted only in false hybrid seeds which, after their germination, proved to be quite matromorphic representing the traits characteristic of their female parent. Chromosome countings made in their soma revealed that they had exactly the same number as that found in the maternal species. From the reasons described later there is little doubt that such individuals originated from the unfertilized egg cells developed parthenogenetically, or more correctly speaking, perhaps, gynogenetically by the stimulation of the sperm-nuclei of different species used as the pollen parent and followed by the doubling of chromosomes in their earliest stage of cleavage. The details have already been reported by TERA0 (1934) with an account from the viewpoint of practical plant-breeding.

#### 1. $F_1$ *B. campestris* ♀ × *B. oleracea* ♂ (COF<sub>1</sub>)

Four  $F_1$  progenies were raised in a number of crosses referred to above (Table IA), and called COF<sub>1</sub>-I, COF<sub>1</sub>-II, COF<sub>1</sub>-III, and COF<sub>1</sub>-IV respectively. Of these the two  $F_1$ -plants, COF<sub>1</sub>-I and COF<sub>1</sub>-II, which were obtained in 1930 and reached their maturation stage in the early part of summer in 1931, were kept alive by a careful management until the summer of 1932 when they reached again their flowering stage. Vegetative propagation of the  $F_1$  hybrids by cutting<sup>(1)</sup> has also been attempted by the author and he succeeded in obtaining the similar  $F_1$ -plants, six from COF<sub>1</sub>-I and sixteen from COF<sub>1</sub>-II. This method enabled the author to secure a considerable amount of  $F_2$  seeds from the two  $F_1$  hybrids which are almost sterile. Both of the  $F_1$  original stocks and the six daughter

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(1) The method of cutting is as follows: from the  $F_1$ -plants the axes of the racemes bearing the matured pods were cut off and they were transplanted in a shadowy cool place. Then some dormant buds will arise in the axils of the upper leaves and develop into rosette-form. They are cut off and fastened down in damp sand and kept in a suitable condition until their roots are formed.

TABLE I A

Combination	Year	Variety name of female parent	Variety name of male parent
<i>campestris</i> ♀ × <i>oleracea</i> ♂	1930*	Enuma-Zairai	Komoti-Kanran
	1931	"	"
	"	Hokkai	Habotan
	1932	Yokkaiti-Marubasyu	Komoti-Kanran
	"	Enuma-Zairai	"
	"	Tyamogarashi	Habotan
	1933	Yasu-Zairai	Komoti-Kanran
	"	Isobe-Zairai	Sadaya-Kanran
	"	Naniwa-Syu	Habotan
			Total
<i>oleracea</i> ♀ × <i>campestris</i> ♂	1932	Komoti-Kanran	Enuma-Zairai
	"	Habotan	"
	1933	Sadaya-Kanran	Tyamogarasi
			Zyun'an-Hakusai
			Total
<i>napus</i> ♀ × <i>oleracea</i> ♂	1930*	Aduma	Habotan
	1931	Yokkaiti-Kurodane	"
	"	"	Komoti-Kanran
	"	Hokkaido-Syu	Habotan
	1932	Yokkaiti-Kurodane	Komoti-Kanran
	"	Aduma	"
	"	"	Habotan
	"	"	"
			Total
<i>oleracea</i> ♀ × <i>napus</i> ♂	1931	Habotan	Aduma
	"	"	Yokkaiti-Kurodane
			Total
<i>napus</i> ♀ × <i>campestris</i> ♂	1932	Ensyu-Kurodane	Aburakake-Syusi
	"	Mutumi-Bansei	Kin-Natane
	"	Wase-Tyosen	Kasima-Zairai
	"	Huzi-Syu	Mie-Zairai
			Total

\* The data in this year were consumed by the fire which broke out at Kōnosu Farm in 1930.

TABLE I A (Continued). Results of crosses

No. of flowers pollinated	No. of seeds obtained	No. of seeds sown	No. of seeds germinated	No. of F <sub>1</sub> hybrids obtained	No. of matromorphic individuals	Culture No. of F <sub>1</sub> hybrids
—	—	—	2	2	0	COF <sub>1</sub> -I & II COF <sub>1</sub> -III COF <sub>1</sub> -IV
110	3	3	1	0	1	
73	8	8	1	1	0	
97	1	1	1	1	0	
42	1	1	0	0	0	
51	0	0	0	0	0	
111	4	4	4	0	4	
165	6	6	5	0	5	
83	3	3	1	0	1	
732	26	26	15	4	11	
134	0	0	0	0	0	
48	0	0	0	0	0	
51	0	0	0	0	0	
155	7	7	4	0	4	
388	7	7	4	0	4	
—	—	—	6	2	4	NOF <sub>1</sub> -I & II NOF <sub>1</sub> -III
41	8	8	2	0	2	
65	4	4	1	0	1	
422	27	16	5	0	5	
130	2	2	2	0	2	
91	1	1	1	1	0	
57	0	0	0	0	0	
102	0	0	0	0	0	
908	42	31	17	3	14	
57	0	0	0	0	0	
24	2	2	0	0	0	
81	2	2	0	0	0	
24	368	100	83	83	0	NCF <sub>1</sub> -I NCF <sub>1</sub> -II NCF <sub>1</sub> -III NCF <sub>1</sub> -IV
20	644	100	47	47	0	
55	576	100	84	84	0	
41	667	100	89	99	0	
140	2255	400	303	303	0	

TABLE I B

Combination	Year	Variety name of female parent	Variety name of male parent
<i>campestris</i> ♀ × <i>napus</i> ♂	1932 " "	Kin-Natane Kasima-Zairai Mie-Zairai	Mutumi-Bansei Wase-Tyōsen Huzi-Syu  Total
<i>carinata</i> ♀ × <i>oleracea</i> ♂	1931 1932 "	Harron " "	Habotan Komoti-Kanran "  Total
<i>oleracea</i> ♀ × <i>carinata</i> ♂	1931	Habotan	Harron
<i>carinata</i> ♀ × <i>nigra</i> ♂	1933	Harron	nigra
<i>napus</i> ♀ × <i>carinata</i> ♂	1932	Aduma	cadisabeba
<i>carinata</i> ♀ × <i>napus</i> ♂	1932	cadisabeba	Aduma
<i>juncea</i> ♀ × <i>carinata</i> ♂	1931 1932	Kurosyusi Kigarsi	Harron cadisabeba  Total
<i>carinata</i> ♀ × <i>juncea</i> ♂	1931	Harron	Kigarsi

plants obtained from COF<sub>1</sub>-I died in late summer of 1932, though some from COF<sub>1</sub>-II survived till now. The other two, COF<sub>1</sub>-III and COF<sub>1</sub>-IV, failed to propagate vegetatively, and died soon after their maturation.



TABLE I B (Continued). Results of crosses

No. of flowers pollinated	No. of seeds obtained	No. of seeds sown	No. of seeds germinated	No. of F <sub>1</sub> hybrids obtained	No. of matromorphic individuals	Culture No. of F <sub>1</sub> hybrids
39	283	100	6	6	0	CNF <sub>1</sub> -I
46	858	100	23	23	0	CNF <sub>1</sub> -II
34	428	50	24	24	0	CNF <sub>1</sub> -III
119	1569	250	53	53	0	
40	1	1	0	0	0	CaOF <sub>1</sub> -I CaOF <sub>1</sub> -II
136	8	8	5	3	2	
72	2	2	2	2	0	
248	11	11	7	5	2	
49	7	6	0	0	0	
44	21	17	17	17	0	CaNiF <sub>1</sub>
55	2	2	2	1	1	NCaF <sub>1</sub>
35	3	3	0	0	0	
83	388	67	21	19	2	JCaF <sub>1</sub> -I JCaF <sub>1</sub> -II
58	60	60	5	5	0	
141	448	127	26	24	2	
94	6	2	0	0	0	

The phenotypical traits displayed by the four F<sub>1</sub>-plants are intermediate between those of the parental species. It is a matter of great interest that they, as a whole, closely resembled *B. napus* and could not readily be distinguished from the latter at any stage

of growth before they reached their flowering time. Although slight variations were noted among them concerning the leaf colour, flower size, length of the inflorescence axis, and flowering time, they were exactly to be distinguished from one another by the degree of their fertility. The plant COF<sub>1</sub>-I was highly sterile, if not completely, setting no seeds at all when selfed within paper-bags, and even after open pollination it failed to offer any F<sub>2</sub> progenies in the



Fig. 8. COF<sub>1</sub>-I.



Fig. 9. COF<sub>1</sub>-II.

first year. In the next summer, however, F<sub>2</sub> seeds were secured by open pollination from the stock which has survived as well as from the daughter plants obtained by cutting. The plants COF<sub>1</sub>-II and COF<sub>1</sub>-III were partially fertile, though the latter surpassed the former considerably in the faculty of producing F<sub>2</sub> progenies. Both of them also gave no seeds when selfed within paper-bags. The fourth plant, COF<sub>1</sub>-IV, on the contrary, was completely fertile and

well-formed seeds were easily secured either in selfing within the paper-bags as well as by uncontrolled pollination.

Pollen grains produced on each of the  $F_1$ -plants were examined with aceto-carmin, the result of which was widely different accord-



Fig. 10.  $COF_1$ -III.

ing to the degree of their fertility. Table II shows the percentage of normal pollen grains observed in each case. The pollen grains of normal shape which are deeply stainable with carmine were taken for normal, and the empty or shrivelled ones for abortive. The under-

lying causes of these remarkable differences were cleared up by the karyological investigations.



Fig. 11. COF<sub>1</sub>-IV.

TABLE II  
Pollen grain investigation in COF<sub>1</sub>

Individual	No. of normal pollen grains	No. of abortive pollen grains	% of normal pollen grains
COF <sub>1</sub> -I	100	1253	7.4
COF <sub>1</sub> -II	1000	1510	39.8
COF <sub>1</sub> -III	1000	359	73.5
COF <sub>1</sub> -IV	1000	38	96.3

To the author's great surprise the four  $F_1$  individuals differed radically in their chromosome constitution. The results of chromosome counting in their root-tip cells, except those of COF<sub>1</sub>-III which did not show any clearly countable metaphase plate, are as follows:

TABLE III  
Zygotic numbers of chromosomes in COF<sub>1</sub>

$F_1$ individual	Zygotic number of chromosomes	Number of extra chromosomes
COF <sub>1</sub> -I	19	0
COF <sub>1</sub> -II	28	9
COF <sub>1</sub> -III	—	—
COF <sub>1</sub> -IV	38	19

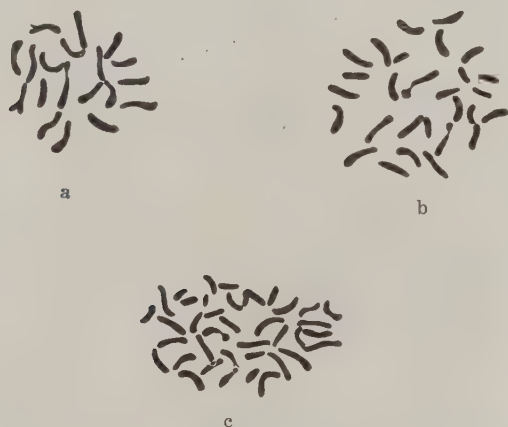


Fig. 12. Somatic metaphases in the root-tip cells of COF<sub>1</sub>s. a, COF<sub>1</sub>-I ( $2n=19$ ). b, COF<sub>1</sub>-II ( $2n=28$ ) c, COF<sub>1</sub>-IV ( $2n=38$ ). ca.  $\times 2000$ .

The observation at heterotypic metaphase in the meiosis of COF<sub>1</sub>-III, however, indicated clearly that it had 29 chromosomes as its diploid number. At first the author believed this peculiar phenomenon to be due to some unreduced gametes produced on each



side of the parents. Really a pure line of species under natural conditions often produces giant pollen grains carrying diploid or tetraploid set of chromosomes as has been reported by FUKUSHIMA (1931) in *Brassica japonica* L.; he thinks that they are derived from tetraploid or octoploid pollen mother cells which have originated from the archesporial cells undergoing somatic doubling. In the root-tip cell division of the parental species there were found frequently a group of tetraploid cells which showed double number of somatic chromosomes in the nuclear plates, though in the microsporogenesis, as far as the investigated materials were concerned, they presented neither a single tetraploid pollen mother cell nor the slightest irregularity which tends to give rise to an unreduced gamete. The pollen grains were of uniform size, showing no peculiar giant ones. Judging from these facts their macrosporogenesis, although no investigation has been made about it, can be regarded also to be regular and the frequent occurrence of an unreduced embryo-sac is not easily accepted. In the parental species under discussion, therefore, the formation of unreduced gametes is considered to be out of question. Hence it is very natural to regard that both the unreduced micro- and megagamete have no rôle for the production of these peculiar  $F_1$  hybrids. A quite similar phenomenon was noted in the cross *B. carinata* ♀ × *B. oleracea* ♂ giving rise to a hybrid with one extra set of *oleracea*-chromosomes where irregularities were never observed in the meiosis of the parent. When the reports of JØRGENSEN (1928) and NOGUCHI (1928) are taken into consideration, the facts might perhaps be explained to be due to some anomalous mode of fertilization as will be discussed later on.

#### *Meiosis in COF<sub>1</sub>-I*

A mode of division quite similar to that in the haploid *B. napus* reported by MORINAGA (1933) is observed in the meiosis in COF<sub>1</sub>-I, except the fact that the number of gemini here formed is 8, thus exceeding by one that observed in the former. The development of heterotypic spindles goes on very irregularly. There appears a varying number of bivalents ranging from 0 to 8 in the equatorial region, and the corresponding number of univalents from 19 to 3 scattered throughout the entire spindle region. The appearance of the gemini in varying number may also be explained to be due to the weak affinity between the members of the two genomes just as in the

case of the haploid. The division is observed to proceed after the scheme of *Triticum-Secale* (KIYHARA, 1931). Table IV shows the frequency distribution of chromosomes determined according to 64 clearly differentiated homotypic daughter plates. One large nuclear

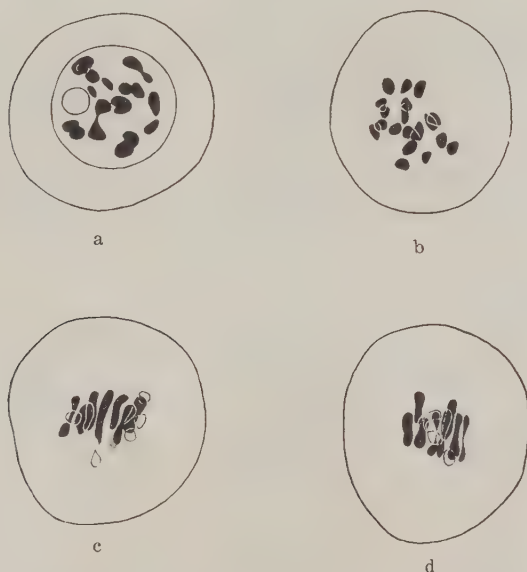


Fig. 13. Reduction division in COF<sub>1</sub>-I. a, diakinesis. b, heterotypic metaphase presenting 19 unpaired chromosomes. c and d, heterotypic metaphase showing 7 (c) and 8 (d) bivalents. ca.  $\times 2000$ .

TABLE IV

Frequency distribution of the number of chromosomes in homotypic metaphase of COF<sub>1</sub>-I

No. of chromosomes on the homotypic spindle	8	9	10	11	12	Average
Frequency	8	22	21	11	2	9.6

plate with 19 or 20 chromosomes were frequently met with at homotypic metaphase. These are obviously due either to the regression which occurred in the heterotypic division or to the complete union of two spindles.

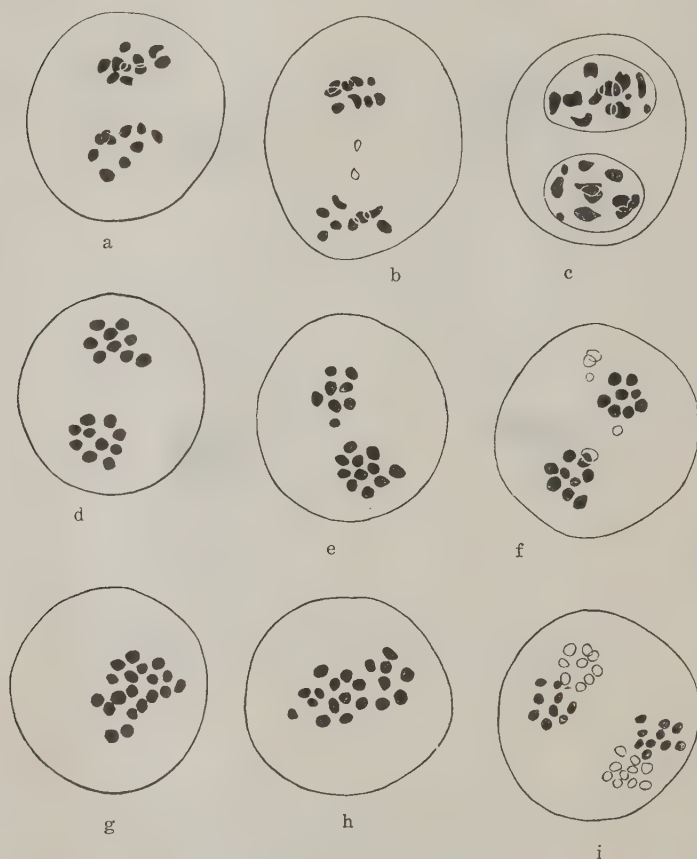


Fig. 14. Reduction division in COF<sub>1</sub>-I. a and b, heterotypic anaphase. c, interkinesis. d-f, polar views of homotypic metaphases, some stray chromosomes out of the daughter nuclear plates are observed in f. g, a large nuclear plate with 19 chromosomes caused by the regression. h, a large nuclear plate formed by the complete union of two spindles. i, homotypic anaphase, ca.  $\times 2000$ .

*Meiosis in COF<sub>1</sub>-II*

14 to 19 chromosomes are found scattered in the nuclear cavity of the pollen mother cells undergoing diakinesis, though their valency is not able to be determined with certainty. About nine of them are always greater in volume than the rest, and a few of them are apparently trivalent. In polar views of the heterotypic spindles the nine chromosomes are observed arranging themselves evenly on the equatorial surface, but the remaining ones take their position on the spindle quite at random. From their shape and position the latter are obviously univalent varying in number from 5 to 10, the frequency of which was determined on 58 heterotypic spindles as shown in the following table. By the examination of a number of side views at

TABLE V  
Frequency of the number of univalents observed in  
58 heterotypic spindles of COF<sub>1</sub>-II

No. of univalents on heterotypic spindle	5	6	7	8	9	10	Average
Frequency	16	14	14	6	6	2	6.6

this stage the valency of these nine chromosomes could be determined. Of these 0 to 5 are really the trisomes presenting peculiar shape, mostly that like heterochromosome, as illustrated in the figures, while the remaining ones are obviously the bivalents ranging from 4 to 9, though the trivalents are not always easily to be distinguished from the bivalents. Their number is best determined by counting that of univalents present on the spindle and calculating as follows: 10 univalents mean no trisomic association ( $9_{II} + 10_I$ ), 9 the presence of one trivalent ( $1_{III} + 8_{II} + 9_I$ ), 8 that of two trivalents ( $2_{III} + 7_{II} + 8_I$ ), etc.; summing up such data the metaphasic configuration in this hybrid can be represented as

$$(0-5)_{III} + (9-4)_{II} + (10-5)_I.$$

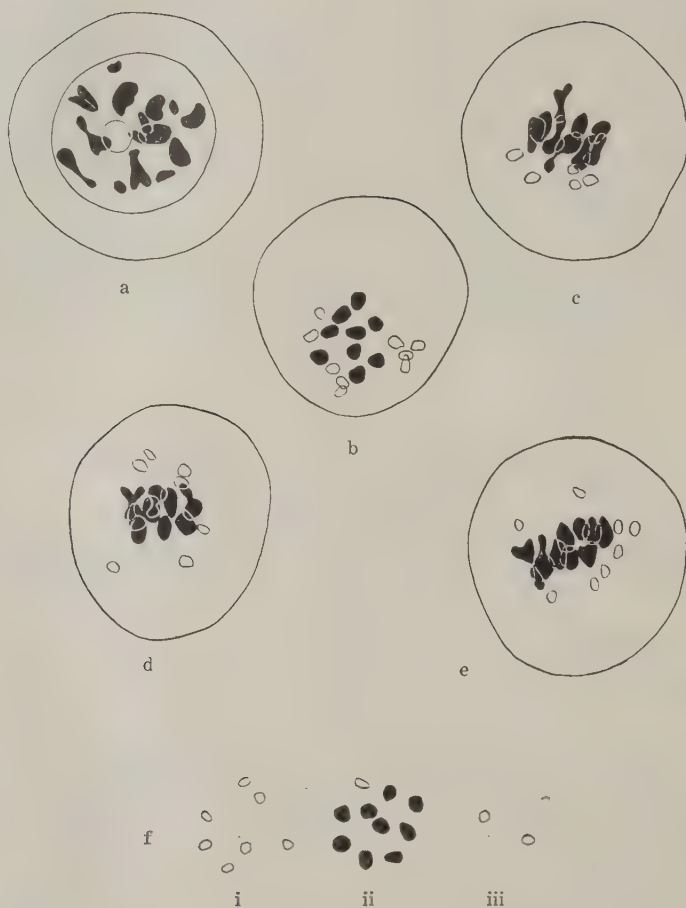


Fig. 15. Reduction division in  $\text{COF}_1\text{-II}$ . a, diakinesis. b, polar view of heterotypic metaphase with 9 associated chromosomes on the equator and 9 univalents at their random position. c-e, side views of heterotypic metaphase showing 5, 7, and 8 univalents respectively, in each some peculiar shaped trivalents are observed. f, polar view of heterotypic metaphase observed at three different foci: i, 7 univalents (upper focus); ii, 9 bivalents and 1 univalent (middle focus); iii, 2 univalents (lower focus). ca.  $\times 2000$ .



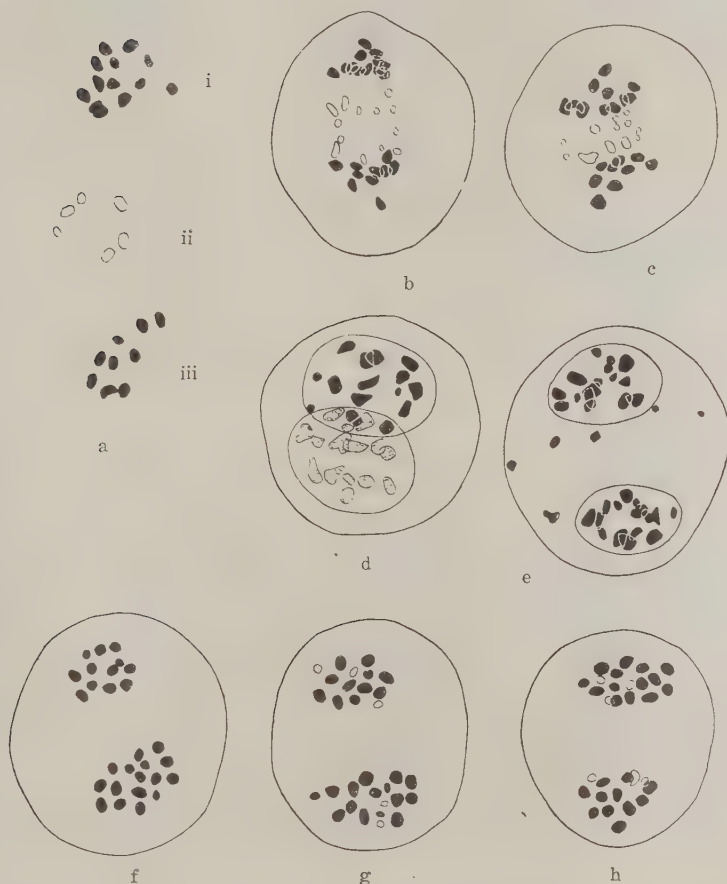


Fig. 16. Reduction division in COF<sub>1</sub>-II. a, heterotypic anaphase observed at three different foci: i, upper focus; ii, middle focus; iii, lower focus, in the middle focus 6 univalents arranged in a ring are observed. b and c, heterotypic anaphases showing the splitting of univalents. d and e, interkinesis. f, homotypic metaphase showing 16 and 12 chromosomes in each daughter plate. g and h, homotypic metaphase showing stray chromosomes out of the plate. ca.  $\times 2000$ .

The later stages of the division are observed to correspond to *Pilosella*-type. A complete union of two spindles at homotypic metaphase is also noted here frequently which results in the formation of dyads. The frequency distribution of chromosomes at this stage is shown in the following table.

TABLE VI  
Frequency distribution of the number of chromosomes observed  
in 66 homotypic daughter plates of COF<sub>1</sub>-II

No. of chromosomes on the daughter plate	9	10	11	12	13	14	15	16	17	18	19	Aver.
Frequency	0	1	2	6	12	13	16	8	5	2	1	14.4

### *Meiosis in COF<sub>1</sub>-III*

At diakinesis 19 chromosomes are clearly recognizable. The heterotypic spindles are observed to be quite uniform. In polar views ten deeply stained round chromosomes which are presumably bivalent are always found forming the nuclear plate in quite regular manner, and nine univalents lying on the periphery of the plate or scattered at different places of the spindle are also seen. The exact valencies of these chromosomes can be determined with no difficulty in side views of the same stage or of the early anaphase. The stretched form of the ten deeply stained chromosomes along the spindle axis and the bar shape of the nine scattered, comparatively lightly stained ones confirm the above assumption of 10<sub>II</sub> + 9<sub>I</sub> to be correct. The chromosome behaviors observed at later stages are also of typical *Pilosella*-type. Table VII shows the frequency distribution of chromosomes observed in 89 homotypic daughter plates.

TABLE VII  
Frequency distribution of the number of chromosomes  
in homotypic metaphase of COF<sub>1</sub>-III

No. of chromosomes on the homotypic spindle	10	11	12	13	14	15	16	17	18	19	Aver.
Frequency	2	3	7	12	17	22	15	8	2	1	14.5

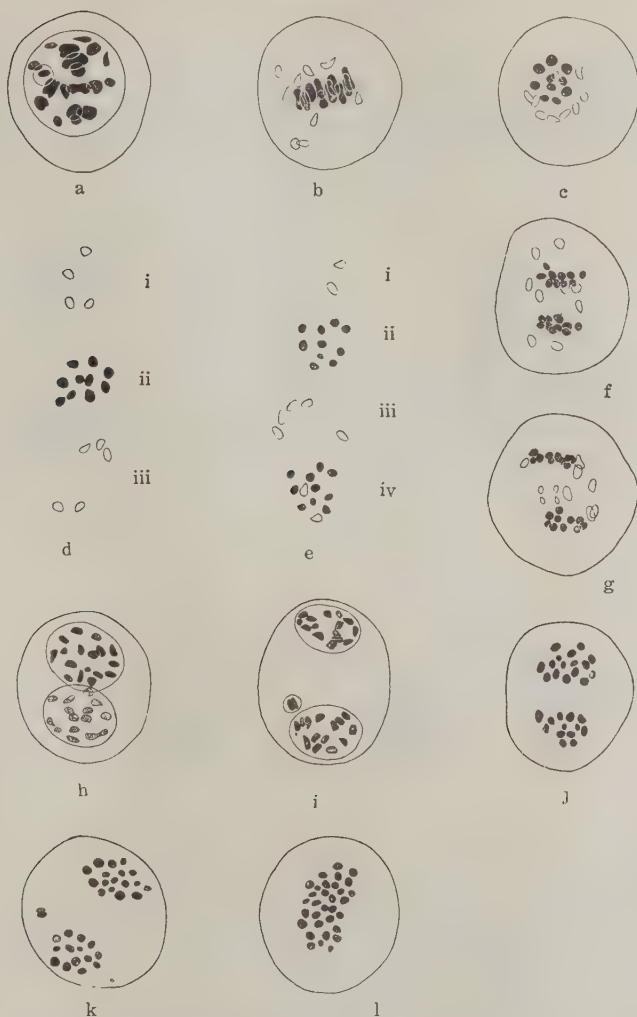


Fig. 17. Reduction division in COF<sub>1</sub>-III. a, diakinesis. b and c, side and polar views of heterotypic metaphase. d, polar view of heterotypic metaphase observed at three different foci: i, 4 univalents (upper focus); ii, 10 bivalents forming the nuclear plate (middle focus); iii, 5 univalents (lower focus). e, polar view of heterotypic anaphase observed at 4 different foci: i, 2 univalents (uppermost focus); ii, 10 disjoined halves of bivalents (upper focus); iii, 5 univalents (lower focus); iv, 10 disjoined halves of bivalents and 2 univalents (lowermost focus). f and g, heterotypic anaphases. h and i, interkinesis. j and k, homotypic metaphases. l, one large nuclear plate caused by the complete union of two spindles. ca.  $\times 1500$ .

*Meiosis in COF<sub>1</sub>-IV*

At diakinesis 19 gemini are observed scattered in the nuclear area around one large nucleolus. The heterotypic spindles are quite regular with 19 bivalents which are arranged evenly on the equatorial

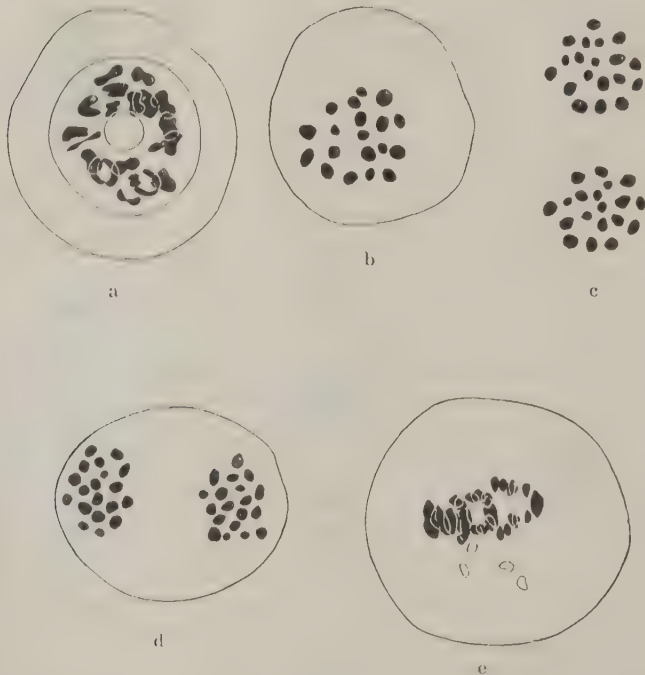


Fig. 18. Reduction division in COF<sub>1</sub>-IV. a, diakinesis. b, polar view, of heterotypic metaphase with 19 bivalents. c, polar view of heterotypic anaphase showing each group of 19 disjoined halves of bivalents. d, homotypic metaphase. e, early heterotypic anaphase showing 4 unpaired chromosomes. ca.  $\times 2000$ .

plane. Every stage of division investigated scarcely differs from that observed in pure 19-chromosomal species except the fact that 2 to 4 chromosomes rarely fail to pair at heterotypic metaphase, thus appearing as univalents.

As already noted, the individual COF<sub>1</sub>-II has 28 chromosomes as its diploid number instead of 19, containing 9 extra chromosomes. In the heterotypic metaphase nine bivalents are always formed by 18 among the 28 chromosomes, leaving the remaining 10 unpaired, but with a tendency to the formation of 0 to 5 trisomes. The latter fact suggests strongly that the 9 extra chromosomes must be identical with the 9 which constitute the *oleracea*-genome and that the trisomic associations are due to their weak affinity with the members of the *campestris*-genome as observed in the meiosis of COF<sub>1</sub>-I. COF<sub>1</sub>-II is, therefore, a triploid hybrid carrying one *campestris*- and two *oleracea*-genomes.

Although the author failed to determine the exact chromosome number of COF<sub>1</sub>-III in its somatic division, the facts above described show that it has 29 chromosomes in its diploid state. Moreover the configuration with 10 bivalents invariably formed and 9 scattered univalents shows that it is also a triploid hybrid which consists of one *oleracea*- and two *campestris*-genomes.

It is a noticeable fact that in COF<sub>1</sub>-I which contains one *campestris*- and one *oleracea*-genome, the varying number of gemini, of which 8 is the highest, is recognized, though in COF<sub>1</sub>-II which carries one *campestris*- and two *oleracea*-genomes it is somewhat weakened resulting in the formation of 0 to 5 trisomes, while in COF<sub>1</sub>-III where the doses of the two genomes are just reverse the 10 bivalents formed by the two *campestris*-ones never associate with the member of the other, showing no affinity at all.

As judged from the meiosis carried out in COF<sub>1</sub>-IV, it is obviously a tetraploid hybrid or an amphidiploid containing both *campestris*- and *oleracea*-genome in duplicated state. Whatever the mechanism of duplication may be, it is noteworthy that the number of chromosomes found in COF<sub>1</sub>-IV is equal to that of *B. napus*, and its phenotypical characters are in every respect quite similar to those common to *napus* varieties.

The degree of pollen abortion in the 4 F<sub>1</sub>-plants has been markedly different from each other. From the karyological observations this may be explained to be due to the random assortment of the parental chromosomes as indicated below. In COF<sub>1</sub>-I the chance for the complete separation of both genomes is very slight, consequently the overwhelming majority of young pollen cells produced on it will con-



sist of those carrying an incomplete or an unbalanced, recombined set of chromosomes, which degenerate without showing any further development or grow into shrivelled, non-functioned grains. Only a very few of them carrying a set which is complete or nearly so develop and reach their maturity, together with those of dyad origin possessing the entire genomes of both parents. In COF<sub>1</sub>-II a complete separation of the nine paired chromosomes formed by the two *oleracea*-genomes is also hindered frequently by the occasional trisomic associations with the member of the other genome. The result is the formation of microspores having various chromosome complexes, whence the percentage of normal pollen grains is considerably lower than that presented by COF<sub>1</sub>-III. Because in the latter the separation of *campestris*-genomes is always performed without any hinderance, pollen cells then formed carry, at least, a complete set of *campestris*. In the amphidiploid COF<sub>1</sub>-IV the reduction division is so regularly performed that the pollen formation differs scarcely from that of pure *napus* varieties.

## 2. F<sub>1</sub> *B. napus* ♀ × *B. oleracea* ♂ (NOF<sub>1</sub>)

The three F<sub>1</sub>-plants secured were so strongly matroclinous that in their early stage of growth the author was doubtful if he had really to do with hybrids. In every stage of growth they were of the general habit of *B. napus* and their heterozygosity was characterized, only by their low fertility and late flowering. Examination on pollen grains revealed that about their 30% were normal. A considerable part of the pods borne on them were empty, showing some traces of ovules which had degenerated in their early stage of development, and besides contained some shrivelled seeds which did not germinate at all. The numerical data concerning their fertility was obtained only from the individual NOF<sub>1</sub>-III, which was about 9%, giving 78 well developed seeds in 882 ovules examined.

No investigation on somatic mitosis has been made in any of the F<sub>1</sub> individuals. The meiotic division has been examined chiefly on the individual NOF<sub>1</sub>-III.

A similar chromosome behavior was noted here as in that observed in the meiosis of COF<sub>1</sub>-II which contained one *campestris*-

and two *oleracea*-genomes having the same zygotic number of chromosomes (28) as *napus-oleracea* hybrids. Heterotypic metaphases show always nine associated chromosomes including 0 to 5 trisomes, and a variable number of univalents ranging from 5 to 10, the frequency



Fig. 19. a, *B. napus* L. var. *oleifera* DC., "Aduma". b,  $F_1$  *napus* ♀ × *oleracea* ♂, NOF<sub>1</sub>-III. c, *B. oleracea* L. var. *acephala* DC., "Habotan."

of their appearance agreeing completely with that noted in COF<sub>1</sub>-II. Also the same images of *Pilosella*-type division are observed at later stages; to avoid unnecessary repetition only a few figures are given here.

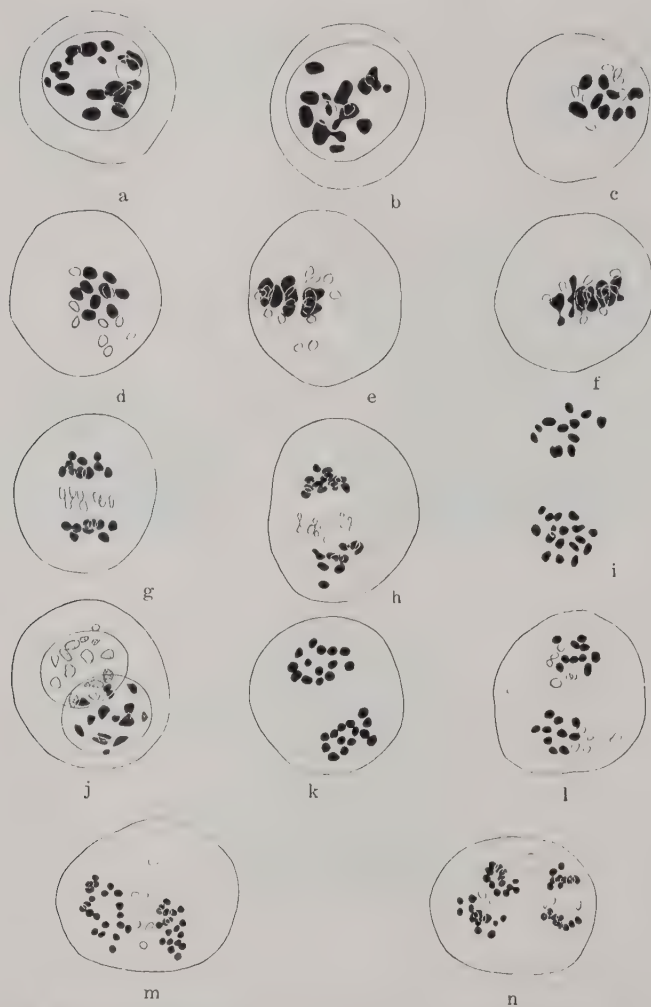


Fig. 20. Reduction division in NOF<sub>1</sub>-III. a and b, diakinesis. c and d, polar views of heterotypic metaphase with 7 and 10 univalents. e and f, side views of heterotypic metaphase with 10 and 7 univalents. g and h, heterotypic anaphases showing lagging and splitting univalents. i, polar view of heterotypic anaphase showing 17 chromosomes in one pole and 12 in the other. j, interkinesis. k, homotypic metaphase showing the equal chromosome distribution of 14 and 14. l, homotypic metaphase showing stray chromosomes out of the daughter plates. m, homotypic anaphase of a large nuclear plate caused by the complete union of two spindles. n, homotypic anaphase. ca.  $\times 1500$ .

### 3. *B. napus* × *B. campestris* (NCF<sub>1</sub> and CNF<sub>1</sub>)

Crosses between these two species have been made extensively since 1929 in order to obtain a new, early-maturing *napus* variety. As already described (Table I) they are comparatively readily crossable in either direction, and abundant F<sub>1</sub> seeds may be easily secured, though their germination is always better when *B. napus* has been taken for female than in the reciprocal cross.



Fig. 21. a, *B. campestris* L., "Mie-Zairai". b, F<sub>1</sub> *campestris* ♀ × *napus* ♂, CNF<sub>1</sub>-III. c, F<sub>1</sub> *napus* ♀ × *campestris* ♂, NCF<sub>1</sub>-IV. d, *B. napus* L. var. *oleifera* DC., "Huzi-Syu".

In appearance the F<sub>1</sub>-plants obtained in each cross resemble strongly *napus*, but are distinguished from it by their lighter green leaves already in their rosette stage. The time of their flowering is observed to depend upon the nature of *campestris* varieties used in

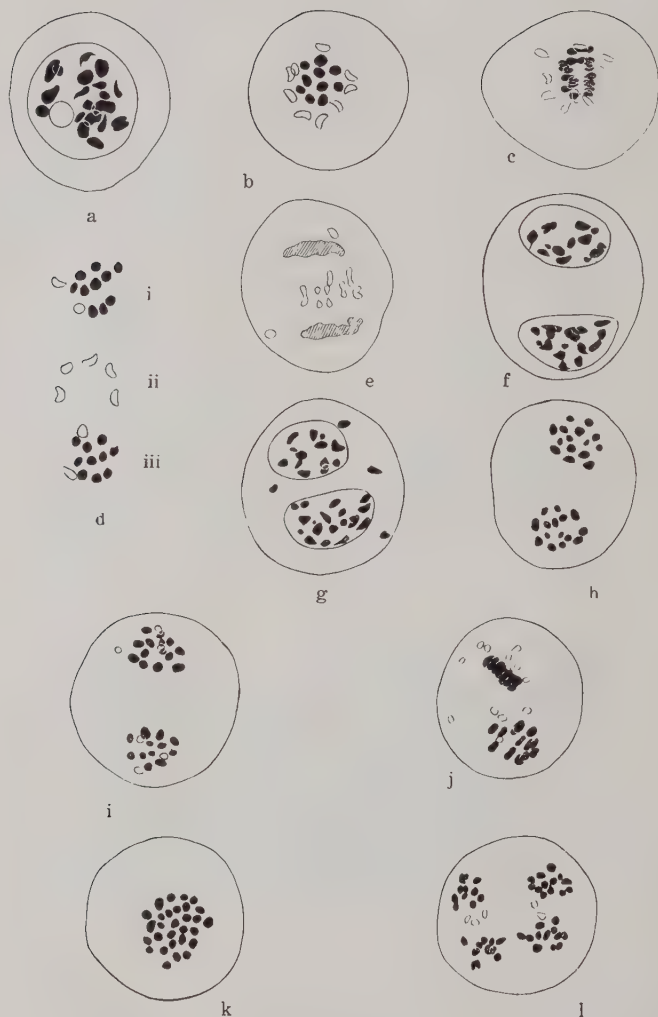


Fig. 22. Reduction division in NCF<sub>1</sub> and CNF<sub>1</sub>. a, diakinesis. b, polar view of heterotypic metaphase with 10 bivalents and 9 univalents. c, heterotypic anaphase showing the disjoining of the 10 bivalents. d, heterotypic anaphase observed at three different foci: i, 10 disjoined halves of bivalents and 2 univalents (upper focus); ii, 5 univalents in a ring (middle focus); iii, 10 disjoined halves of bivalents and 2 univalents. e, heterotypic anaphase showing the splitting of univalents. f and g, inter-kinesis, outward inclusion of chromosomes are observed in g. h-j, homotypic metaphases. k, one large nuclear plate with 29 chromosomes. l, homotypic anaphase. ca.  $\times 1500$ .



the crosses, though always earlier than that of *napus*. Examination of their fertility revealed that in average about 10% of the ovules developed into seeds which were extremely various in size.

No chromosome counting was also made in the soma of  $F_1$ . The chromosome configurations at heterotypic metaphase in the pollen mother cell division are quite uniform, being  $10_{II} + 9_I$  as has been reported by MORINAGA (1929). This is also the case with COF<sub>1</sub>-III in which one *oleracea*- and two *campestris*-genomes coexist. As the detailed description of meiotic figures is nothing but a mere repetition, only a few illustrations are given here.

#### 4. Genome-analysis and experimental formation of *B. napus*

As already mentioned MORINAGA's hybridization experiment has shown that the genome "a" which is commonly seen in *Brassica* is one of the constitutive chromosome sets composing that of *B. napus*. This conclusion is again confirmed here by the configuration of  $10_{II} + 9_I$  observed in the first metaphase of NCF<sub>1</sub> (*napus* × *campestris*). Further, he has suggested in his report of haploid *B. napus* that a weak affinity might exist between the members of the two constitutive genomes "a" and "c" resulting in the formation of 0 to 7 bivalents, though the genome "c" which is composed of 9 chromosomes is of quite unknown origin.

The individual COF<sub>1</sub>-I which resembles closely *B. napus* in its phenotypical characters corresponds to the haploid, not only in the number of chromosomes, but also in their behavior throughout the meiotic division. Here also appears a variable number of gemini at heterotypic metaphase indicating a similar weak affinity existing between the two genomes, "a" (*campestris*) and "c" (*oleracea*). The unexpected occurrence of the two triploid hybrids, COF<sub>1</sub>-II and COF<sub>1</sub>-III, since the genome constitution of the former is  $ac'c'$  and the latter  $aac'$ , enabled the author to examine more closely the composite genome of *B. napus*. Because if the genome of *B. napus* will consist of "a" and "c", the chromosome behavior found in the hybrids NOF<sub>1</sub> (*napus* × *oleracea*) and NCF<sub>1</sub>, should be identical to those found in the above-mentioned two triploid hybrids respectively. In fact the meiosis observed in COF<sub>1</sub>-II and NOF<sub>1</sub> are observed to be, in every respect, identical. In both cases there appear 9 bivalents invariably formed and 10 univalents, the latter with a tendency to the formation of 0 to 5 trisomes with the members of the former.

Also the reduction division is carried out in quite a similar way in COF<sub>1</sub>-III and NCF<sub>1</sub>. Here the configuration at heterotypic metaphase is represented uniformly as 10<sub>II</sub> + 9<sub>I</sub>. Hence it is clear that *B. napus* is an allotetraploid or an amphidiploid having each two complete genomes of *B. campestris* (or of the allied species with 10 chromosomes) and of *B. oleracea*. The notation "c" designated by MORINAGA to denote the 9-chromosomal set in *B. napus* is, therefore, considered hereafter to represent also the genome of *oleracea* ("c'").

It is a matter of great interest that the origin of *B. napus* explained by the foregoing analytical method is confirmed synthetically by the appearance of the fertile tetraploid hybrid (COF<sub>1</sub>-IV) resulting from the cross *B. campestris* ♀ × *B. oleracea* ♂. As has been stated the named individual can not be considered to have been formed by the fusion of unreduced gametes, and it might have probably been produced by the endoduplication which occurred in the earliest zygotic stage. The phenotypical traits represented by it coincide with those characteristic of *napus* and the microsporogenesis observed in it proceeds normally, though with some minor irregularities. Thus it will not be improper to say that *B. napus* has been experimentally formed.

There are similar cases of the formation of constant allopolyploids by somatic doubling in F<sub>1</sub>, such as *Nicotiana digluta* (GOODSPEED and CLAUSEN, 1925) and *B. napocampestris* (FRANDSEN and WINGE, 1932) where the doubling has also occurred in the earliest zygotic stage. FRANDSEN and WINGE regarded the somatic chromosome number of *B. napus* as 18 instead of 19, consequently they reported that of *B. napocampestris* caused by the doubling in the F<sub>1</sub> hybrid between swede (*B. napus* L. var. *sativa rapifera*) and turnip (*B. campestris* L. var. *sativa rapifera*) should be 56 = (18 + 10) × 2. The author, however, cannot agree with this opinion, because the swede cultivated in our breeding yard presents 19 bivalent chromosomes exactly as in other *napus* varieties at heterotypic metaphase of the pollen mother cell division. Hence the number reported should be corrected to 58. Since the constitution of the genome of *B. napus* was known, *B. napocampestris* must be considered to be an allohexaploid consisting of 4a and 2c.

Another case of doubling in the soma of F<sub>1</sub> has been reported by several investigators. JØRGENSEN (1928) has succeeded in obtain-

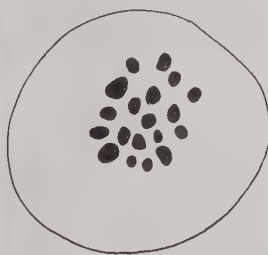
ing fertile *nigrum-luteum* hybrid in *Solanum* through the artificial induction of somatic doubling by decapitating the sterile  $F_1$ . *Primula kewensis* (NEWTON and PELLEW, 1929) originated also from a fertile shoot as the result of a doubling of the chromosomes in the soma

of the sterile diploid hybrid *Primula floribunda* ♀ × *P. verticillata* ♂. The Veitchberry is, according to CRANE and DARLINGTON (1927), a tetraploid probably the result of the fusion of two haploid gametes.

On the other hand constant allopolyploids have arisen frequently through the union of unreduced gametes in highly sterile  $F_1$  hybrids, i.e., through the gametic doubling. To this mode of origin the well-known *Raphano-Brassica* (KARPECHENKO, 1924, 1927, 1928), *Aegilotriticum*



a



b

Fig. 23. a,  $COF_2-Ic-2$ , one of the *napus*-type  $F_2$  progenies from  $COF_1-I$  with 33 somatic and 19 meiotic chromosomes. b, polar view of heterotypic metaphase in the microsporogenesis of  $COF_2-Ic-2$ . ca.  $\times 2000$ .

(TSCHERMAK and BLEIER, 1926; KIHARA and KATAYAMA, 1930; PERCIVAL, 1930), *Brassica-Raphanus* (TERASAWA, 1928, 1932), and *Digitalis mertonensis* (BUXTON and NEWTON, 1928) will belong. Also the following cases are similarly due to the unreduced gametes: *Fragaria bracteata* ♀ × *F. Helleri* ♂ (ICHIJIMA, 1926), *Triticum turgidum* ♀ × *T. villosum* ♂ (TSCHERMAK, 1930), *Triticum vulgare* ♀ × *Secale cereale* ♂ (LEVITSKY and BENETSKAYA, 1929), *Triticum durum* ♀ × *T. monococcum* ♂ (THOMPSON, 1931), *Phleum pratense* ♀ × *P. alpinum* ♂ (GREGOR and SANSOME, 1930), *Nicotiana Tabacum* ♀ × *N. sylvestris* ♂ (RYBIN, 1929), *Nicotiana paniculata* ♀ × *N. rustica* ♂ (LAMMERTS, 1929, 1931), *Hibiscus esculentus* ♀ × *H. Manihot* ♂ (TESHIMA, 1933).

Most  $F_2$  progenies from  $COF_1-I$ , the only diploid hybrid obtained in the cross *B. campestris* ♀ × *B. oleracea* ♂, are found to have 38 somatic chromosomes. Each of these show clearly 19 tightly paired bivalents at heterotypic metaphase. Though the detailed description will be given in another paper, the fact indicates, together with the occurrence of  $COF_1-IV$ , the two possible ways by which *B. napus* has arisen, viz., somatic as well as gametic doubling in  $F_1$ .

##### 5. $F_1$ *B. carinata* ♀ × *B. oleracea* ♂ ( $CaOF_1$ )

Similarly to that noted in the *napus-oleracea* hybrids, the strong matroclinous nature accompanying the remarkable delay in flowering was also displayed here. Despite the variation seen in the degree of the anthocyanin pigmentation in the stems and leaves the five  $F_1$  individuals obtained were quite uniform, except the one numbered as  $CaOF_1-II-2$  which was inclined in its external form somewhat towards the male parent, *B. oleracea*, though the differences from the other four were but slightly perceptible in the early stage of vegetation. Lateness in flowering by about a fortnight was also noted in  $CaOF_1-II-2$ , which remains still in its rosette stage when the axes of the inflorescence of all the rest had already begun to elongate. The  $F_1$ -plants were almost sterile, yielding even on open pollination only 4 to 33 seeds per individual, and the plant  $CaOF_1-II-2$  failed to give any seeds at all. Pollen grain investigation was made on three of them, the results of which are shown in Table VIII.



Fig. 24. a, *B. carinata* BRAUN var. *Harron*, "Abyssinian Mustard". b and c,  $F_1$  *carinata* ♀ × *oleracea* ♂. b,  $CaOF_1-II-1$ . c,  $CaOF_1-II-2$ . d, *B. oleracea* L. var. *gemifera* ZENKER, "Komoti-Kanran".

TABLE VIII  
Pollen grain investigation in  $CaOF_1$

Plant number	No. of normal pollen grains	No. of abortive pollen grains	% of normal pollen grain
$CaOF_1-I-2$	34	599	0.5
$CaOF_1-II-1$	10	556	0.18
$CaOF_1-III-2$	0	609	0



Difference in chromosome constitution of  $F_1$  individuals is again encountered here. Investigation on somatic mitosis in each of the  $F_1$  hybrids revealed that the four individuals namely,  $\text{CaOF}_1\text{-I-1}$ ,  $\text{CaOF}_1\text{-I-2}$ ,  $\text{CaOF}_1\text{-I-3}$ , and  $\text{CaOF}_1\text{-II-1}$  had exactly 26 chromosomes in their metaphase plates in root-tip cells which correspond to the sum of the haploid numbers of both parents, while in  $\text{CaOF}_1\text{-II-2}$  the nuclear plates was provided with 35 chromosomes, thus presenting an extra set of 9 chromosomes.

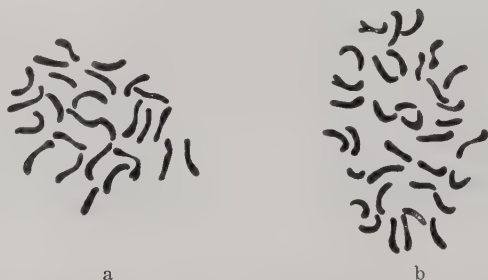


Fig. 25. Somatic metaphases in the root-tip cell division of  $\text{CaOF}_1$ .  
a,  $\text{CaOF}_1\text{-II-1}$  ( $2n=26$ ). b,  $\text{CaOF}_1\text{-II-2}$  ( $2n=35$ ).  
ca.  $\times 2000$ .

The microsporogenesis is observed to be quite uniform in the four  $F_1$ -plants, except  $\text{CaOF}_1\text{-II-2}$ . At metaphase of the heterotypic division the configuration,  $9_{\text{II}} + 8_{\text{I}}$  is clearly observable in each of the pollen mother cells. The division seems to be carried out after *Pilosella*-scheme, though the splitting of univalents at heterotypic anaphase is observed to be rather rare and the equal assortment of 13 and 13 is frequently here met with. Table IV shows the frequency distribution of chromosomes observed on 58 homotypic daughter plates.

TABLE IX  
Frequency distribution of the number of chromosomes  
in homotypic metaphase of  $\text{CaOF}_1\text{-II-1}$

No. of chromosomes on the homotypic spindle	10	11	12	13	14	15	16	17	Average
Frequency	4	44	9	22	8	8	2	1	13.0



Fig. 26. Reduction division  $\text{CaOF}_1\text{-II-1}$  ( $2n=26$ ). a and b, polar and side views of heterotypic metaphase showing the configuration of  $9\text{II}+8\text{I}$ . c-e, heterotypic anaphases. f and g, interkinesis. h-j, homotypic metaphases, some stray chromosomes from the daughter nuclear plates are seen in i and j. k, homotypic anaphase, Ca.  $\times 1500$ .

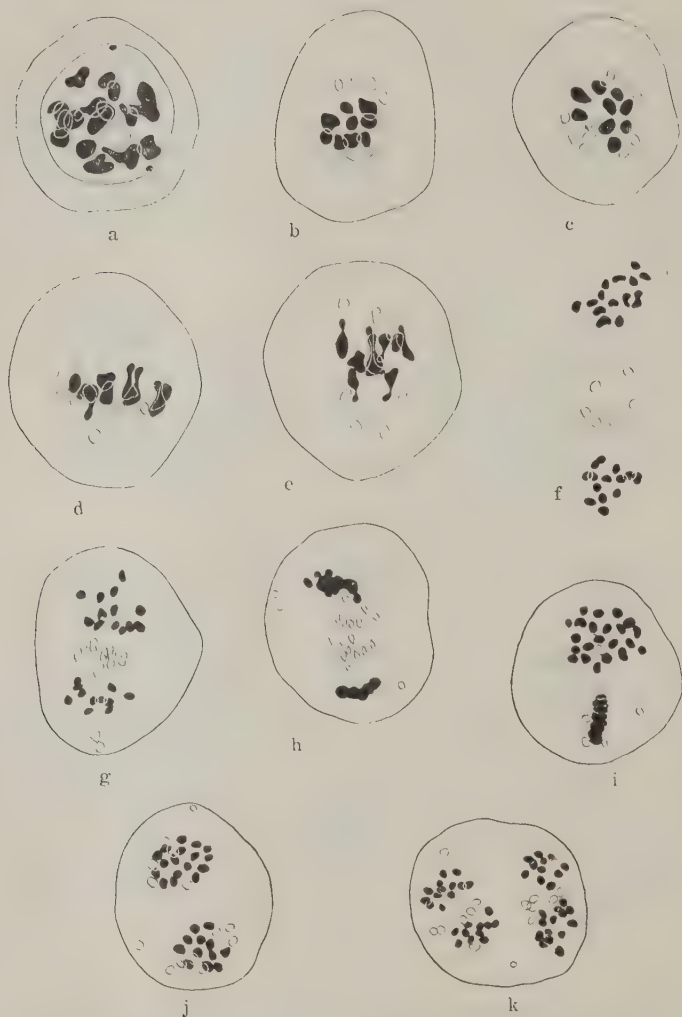


Fig. 27. Reduction division in  $\text{CaOF}_1\text{-II-2}$  ( $2n=35$ ). a, diakinesis. b and c, polar views of heterotypic metaphase with 8 and 11 univalents. d and e, side views of heterotypic metaphase with 9 and 8 univalents (cf. Microphoto i, in the plate). f, heterotypic anaphase observed at three different foci, 6 univalents in a ring arrangement are observed at middle focus. g and h, heterotypic anaphases showing the lagging and splitting of univalents. i and j, homotypic metaphases with some stray chromosomes out from the daughter nuclear plates. k, homotypic anaphase showing lagging daughter univalents in the equatorial region of each spindle. ca.  $\times 1500$ .

In CaOF<sub>1</sub>-II-2 the heterotypic nuclear plates are observed to be composed of 9 associated chromosomes and a variable number of univalents ranging from 8 to 12. The former take their position always exactly on the equatorial plane, and the latter are found mostly on its periphery, though some are scattered on the spindle. Judging from the investigation of about 50 side views, the configuration at this stage can be represented as (9-5)<sub>III</sub> + (0-4)<sub>II</sub> + (8-12)<sub>I</sub>. Here most of the univalents split at late anaphase when the descendants of the associated chromosomes have already reached the polar region, and their daughter halves travel to the two opposite poles. However, some which have failed to arrange themselves on the equator, lying far apart from it seem to be included in either of the poles without splitting. Outward inclusion of daughter univalents and stray chromosomes is observed frequently at interphase. The homotypic spindles develop with considerable irregularity. Above and below the daughter plate formed by the descendants of the associated chromosomes, some minor ones, most of which are supposed to be the daughter univalents, are found scattered at random. On 55 somewhat evenly arranged daughter plates chromosome counting has been made, the result of which is shown in Table X.

TABLE X  
Frequency distribution of the number of chromosomes  
in homotypic metaphase of CaOF<sub>1</sub>-II-2

No. of chromosomes on the homotypic spindle	16	17	18	19	20	21	22	23	Average
Frequency	1	3	5	7	10	15	10	4	20.3

MORINAGA (1933) has succeeded in obtaining a F<sub>1</sub> hybrid in the cross *B. carinata* ♀ × *B. alboglabra* ♂, the latter of which was taken for a monogenomic species having a similar set of chromosomes as found in *B. oleracea*. The hybrid had, contrary to his expectation, 25 somatic chromosomes instead of the expected number 26. At heterotypic metaphase of the microsporogenesis of the hybrid 9 bivalents and 7 univalents were always present. He concluded that one of the two constructive chromosome sets of *B. carinata* is identical to the

set which constitutes *B. alboglabra* or *B. oleracea*, and that perhaps one of the 8 chromosomes constituting the other set was lost by chance in the hybrid investigated.

Leaving off the almost total splitting of univalents observed in the first anaphase of the hybrid reported, the configuration,  $9_{II} + 7_I$ , corresponds to that,  $9_{II} + 8_I$  observed in the present *carinata-oleracea* hybrids. Here his assumption that one of the chromosomes of the other set including the remaining 8 chromosomes was lost, is confirmed.

Judging from the configuration,  $9_{III} + 8_{II}$ , which is frequently met with, the extra set of 9 chromosomes in  $CaOF_1-II-2$  is no doubt identical to the *oleracea*-genome ("c"). The individual is, therefore, a tetraploid hybrid possessing three complete *oleracea*-genomes and an undefined set including 8 chromosomes. The mechanism of the duplication of the genome "c" will be discussed later, together with those noted in the case of *campestris-oleracea* hybrids.

#### 6. $F_1$ *B. carinata* ♀ × *B. nigra* ♂ ( $CaNiF_1$ )

Most of the  $F_1$ -plants obtained were still in their rosette stage when the present report was under press, though some which had previously been put in the greenhouse had reached already their maturation stage and offered sufficient materials for karyological investigation. In their rosette stage they took a *carinata*-like appearance, and their heterozygosity was only characterized by the dark colour of the leaves due to the anthocyanin pigment and the slight crinkling of their surface. As they develop, the intermediate nature was displayed in the morphology of their stems and leaves in more pronounced way, though as a whole they recalled always *carinata*. They were also proved to be highly sterile, and the author could obtain only 3 to 14  $F_2$  seeds by the uncontrolled pollination in the greenhouse.

The somatic number of their chromosomes counted in the root-tip cell division coincides with the sum of the reduced number of both parental species, i.e. 25. At diakinesis of the microsporogenesis 17 chromosomes are always counted, of which 8 are apparently the gemini. The configuration in the following metaphase is, as expected, observed to be quite uniform, being  $8_{II} + 9_I$ . Here the division is carried out also after *Pilosella*-type, but approximates very



much the *Triticum*-type, and very frequently all univalents are observed to split at late anaphase in the equatorial region after the disjoining of bivalents has been completed. In the second metaphase the descendants of the bivalents arrange themselves to form the daughter plates quite regularly, though the daughter univalents scatter themselves above and below the former, and some of them are frequently found far apart in the cytoplasm. Only in a few mother cells in which the splitting of univalents at heterotypic anaphase was rare, the regular development of daughter spindles is observable.



Fig. 28. a, *B. carinata* BRAUN var. Harron, "Abyssinian Mustard".  
b,  $F_1$  *carinata* ♀  $\times$  *nigra* ♂. c, *B. nigra* KOCH.

Here the almost equal distribution of 13 and 12, and of 11 and 14 are met with. Complete union of two daughter spindles leading to the formation of dyads, is frequently noticed at this stage. In the following anaphase many lagging chromosomes are observed, 7, 8, or 9 being most frequent. Some of them are often excluded out from the reforming nuclei.

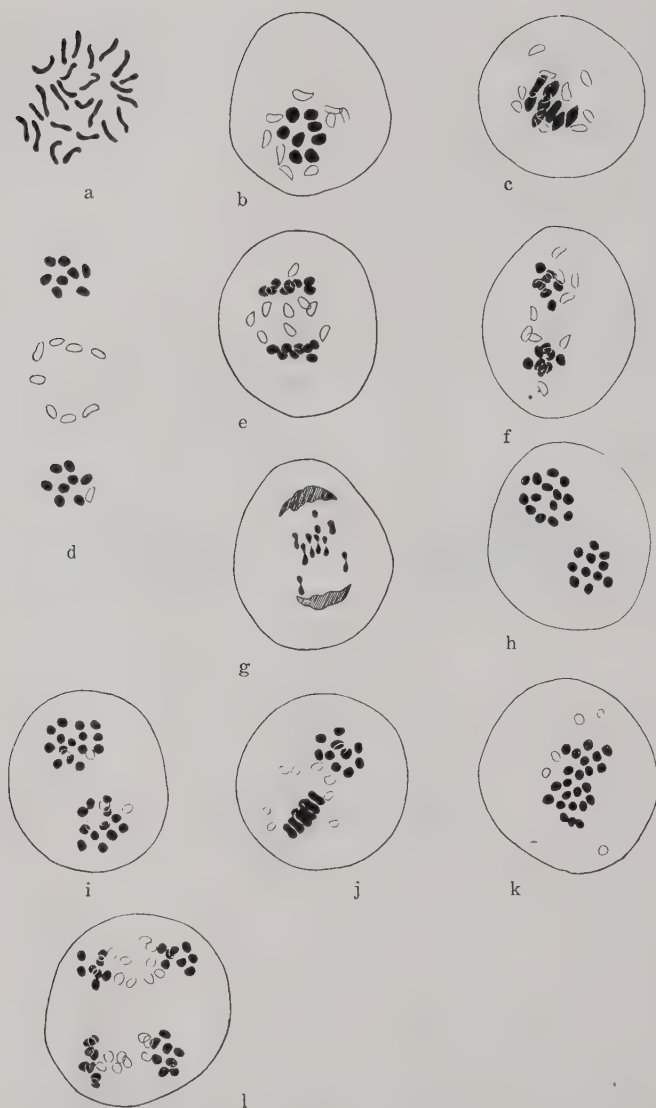


Fig. 29. Somatic and meiotic division in  $\text{CaNiF}_1$ . a, somatic nuclear plate with 25 chromosomes in the root-tip cell division. b and c, heterotypic metaphases showing the configuration of  $8H+9r$ . d, heterotypic anaphase observed at three different foci, in the middle focus 8 univalents are observed arranging themselves in a ring at the equatorial region. e-g, heterotypic anaphases showing the lagging and splitting of univalents. h-j, homotypic metaphases with some stray chromosomes on the spindles. k, a large nuclear plate caused by the complete union of two daughter spindles. l, homotypic anaphase, many laggards are seen. Ca.  $\times 1500$ .

7.  $F_1$  *B. napus* ♀ × *B. carinata* ♂ (NCaF<sub>1</sub>)

As noted in Table IB, a single  $F_1$ -plant was raised. It was of an intermediate type, though nearer to *B. napus* than to the other parent and partially fertile, yielding 53 viable  $F_2$  seeds after open pollination.

Investigation on the somatic mitosis in its root-tip cells revealed that it had 36 chromosomes corresponding to the sum of the gametic numbers of both parents. At diakinesis of the microsporogenesis 22 to 27, rarely 21, chromosomes are found scattered in the nuclear cavity. Although their valency is difficult to be determined with certainty, about nine of them are always greater in volume than the rest, and a few of them are observed to be trivalent. In the following metaphase a group of nine chromosomes are invariably found on the equatorial surface, leaving a variable number of univalents in their scattered position. Of 50 spindles the frequency appearance of the number of univalents was determined as shown in the following table. From the investigation of side views at this stage trisomic

TABLE XI  
Frequency appearance of the number of univalents  
in heterotypic metaphase of NCaF<sub>1</sub>

No. of univalents on the heterotypic spindle	12	13	14	15	16	17	18	Average
Frequency	2	8	12	13	10	3	2	14.8

association was obviously noted in some of the nine chromosomes forming the nuclear plate. This, together with the numerical data above mentioned, determines the configuration at this stage to be

$$(0-6)_{III} + (9-3)_{II} + (18-12)_I.$$

To the great regret of the author, he has failed to secure materials enough for the study of the second division, whence the description is confined to the first metaphase only.



a



b



c

Fig. 30. a, *B. napus* L. var. *oleifera* DC., "Aduma". b,  $F_1$  *napus* ♀ × *carinata* ♂. c, *B. carinata* BRAUN var. *Harron*, "Abyssinian Mustard".

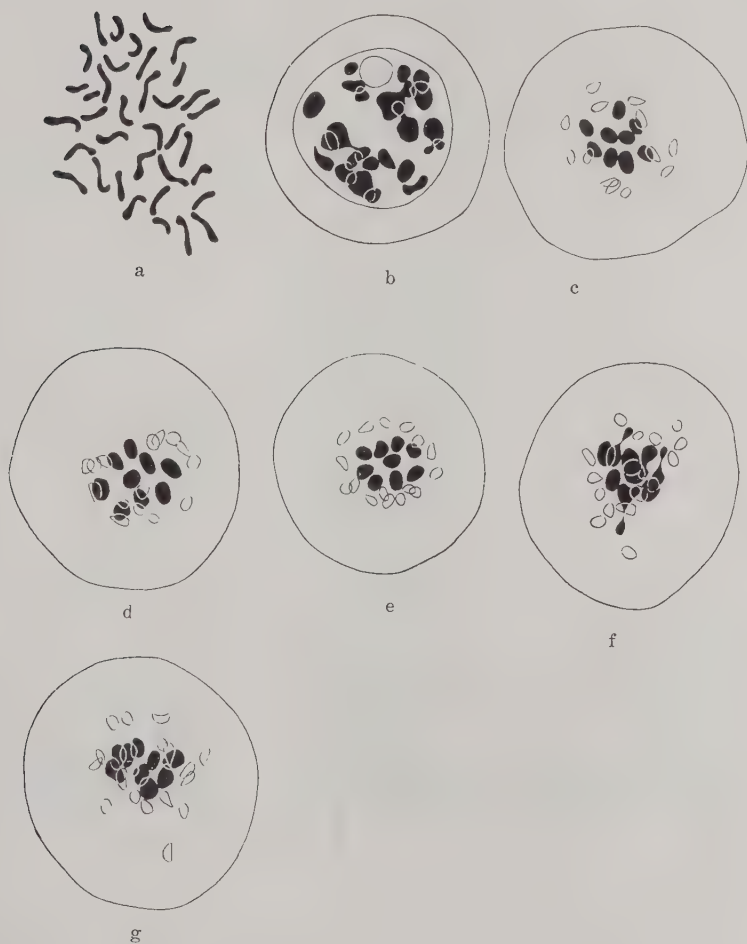


Fig. 31. Somatic and meiotic division in NCaF<sub>1</sub>. a, somatic metaphase with 36 chromosomes in a root-tip cell. b, diakinesis. c-e, polar views of heterotypic metaphase showing 9 associated chromosomes with 13, 15, and 16 univalents respectively. f, a side view of heterotypic metaphase with 14 univalents, 4 of the associated chromosomes are clearly trivalent. g, an oblique view with 18 univalents. Ca.  $\times 2000$ .



### 8. $F_1$ *B. juncea* ♀ × *B. carinata* ♂ (JCaF<sub>1</sub>)

The crossing was successful only in one direction where *B. juncea* was used as the female parent. The  $F_1$  progenies were intermediate between the parental forms, but somewhat nearer to *B. carinata*. They were partially fertile giving more than 100  $F_2$  seeds per individual by uncontrolled pollination, though all the attempts in



Fig. 32. a, *B. juncea* COSS., "Kigarasi". b,  $F_1$  *juncea* ♀ × *carinata* ♂. c, *B. carinata* BRAUN var. *Harron*, "Abyssinian Mustard".

paper-bag selfing were proved to be in vain. They presented in their metaphase plate in root-tip cell division 35 chromosomes, i.e. the sum of the reduced numbers of both parents. The configurations at heterotypic metaphase of the microsporogenesis are observed to be variable. In polar views a varying number of chromosomes ranging from 19 to 27 are recognized at different places, about 9 to 16 of which are considered presumably bivalents taking their position on

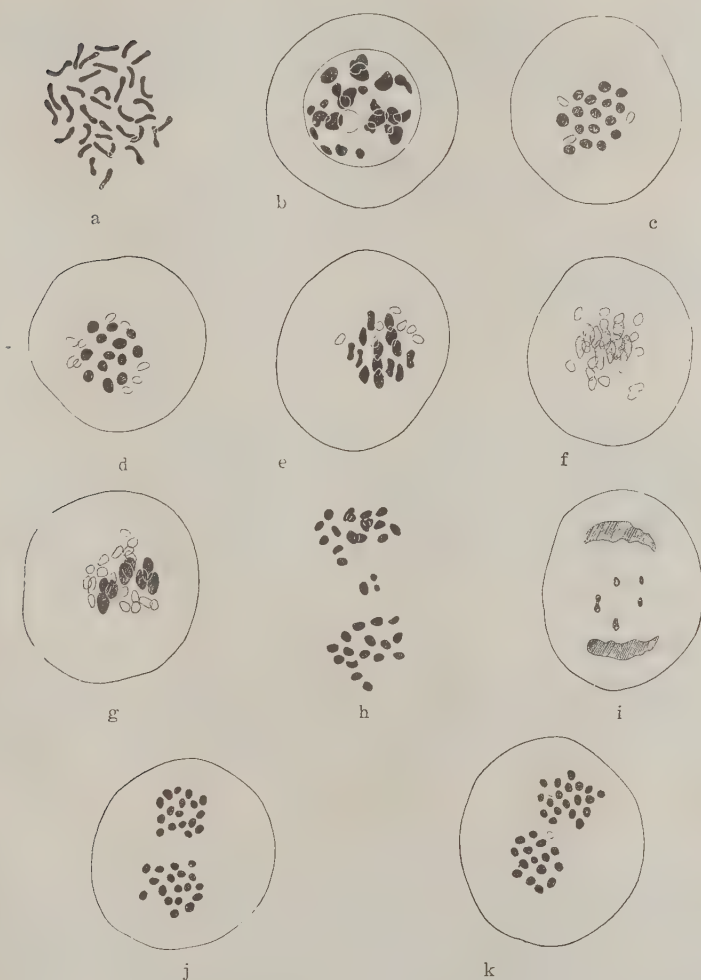


Fig. 33. Somatic and meiotic divisions in JCaF<sub>1</sub>. a, somatic nuclear plate with 35 chromosomes in a root-tip cell. b, diakinesis. c and d, polar views of heterotypic metaphase showing the configurations,  $16_{II}+3_I$  and  $13_{II}+9_I$ , respectively. e-g, oblique views of heterotypic metaphase with  $14_{II}+7_I$ ,  $10_{II}+15_I$ , and  $8_{II}+18_I$  respectively. h and i, heterotypic anaphases showing some univalents splitting. j and k, homotypic metaphases. Ca.  $\times 1500$ .

the equatorial surface and forming the nuclear plates in quite a regular manner. Of 45 well differentiated polar views chromosome countings were made, the result of which is shown in the following table. Owing to the superposition of associated chromosomes it is

TABLE XII  
Total number of chromosomes on heterotypic  
spindle of JCaF<sub>1</sub>

No. of chromosomes on the heterotypic spindle	19	20	21	22	23	24	25	26	27	Average
Frequency	4	8	10	10	5	3	2	1	2	21.8

not easy to determine the exact configuration at this stage from the side views. Several clear oblique views, in which the author was enabled to distinguish the gemini from the unpaired chromosomes with comparative easiness, afford evidence, together with the numerical data above mentioned, that the metaphasic configurations in this hybrid can obviously be represented as

$$(8-16)_{II} + (19-3)_{I}.$$

The material fixed was not suitable for the study of the homotypic division. A few figures observed in some of the well differentiated mother cells indicating the chromosome behaviors during the later stages of division are, however, here presented.

### 9. Genome-analysis of *B. carinata* and of *B. juncea*

For a thorough genome-analysis of a species considered presumably to be an allotetraploid (AABB), KIHARA (1930) propounded the following three criteria: firstly, the configuration at heterotypic metaphase in the F<sub>1</sub> hybrid AABB × AA should be N<sub>II</sub> + n<sub>I</sub> where N is the reduced number of chromosomes of the analysator (AA) and n that of (BB); secondly, in the F<sub>1</sub> AABB × BB it should be n<sub>II</sub> + N<sub>I</sub>; and thirdly, when AABB can be crossed with a species (CC) of quite remote origin to both AA and BB, the heterotypic spindle in the F<sub>1</sub> hybrid AABB × CC should develop with

$(N+n+m)_I$ , where  $m$  is also the gametic number of chromosomes of CC; or, if there occurs a haploid (AB),  $(N+n)_I$  should appear in the named stage.

In the genome-analysis of *B. napus*, as already described, the three conditions mentioned above are satisfied in the  $F_1$  hybrids *B. napus* × analysators as well as in the haploid, although the chromosome behaviors have been complicated by the existence of the weak affinity between the two constitutive genomes, "a" and "c". These relations have also been manifested in the case of *B. carinata*. The zygotic number of chromosomes found in the varieties belonging to the named species is 34 which corresponds exactly to the sum of those of *B. oleracea* and of *B. nigra*. From the configurations in the first metaphase of the microsporogenesis observed in the  $F_1$  hybrid *B. carinata* ♀ × *Raphanus sativus* ♂, MORINAGA has concluded: "Generally speaking such a *carinata*-*Raphanus* hybrid produces no constant bivalents in the microsporogenesis, the fact indicating neither constant affinity between *Raphanus*- and *carinata*-chromosomes, nor conceivable homology between *carinata*-chromosomes themselves....." The fact has also been confirmed by the author in the pollen mother cell division of the  $F_1$  hybrid *B. carinata* ♀ × *Raphanus sativus* ♂ obtained in 1933 as illustrated in Fig. 34. It is, therefore, clear that the configurations,  $9_{II}+8_I$ , and  $8_{II}+9_I$  observed in the two  $F_1$  hybrids, *B. carinata* ♀ × *B. oleracea* ♂ and *B.*

*carinata* ♀ × *B. nigra* ♂, respectively are not the results of autosyndesis, but the positive evidence which indicates the composite nature of *B. carinata* consisting of two different genomes, "c" and "b" (*nigra*). Hence, *B. carinata* is also an allotetraploid whose genome constitution can be represented as  $b'b'cc$ .

Since the two composite genomes of *B. napus* and of *B. carinata* are to be considered as  $aacc$  and  $b'b'cc$  respectively, the chromosome behavior at heterotypic metaphase in the  $F_1$  hybrid *B. napus* ♀ × *B. carinata* ♂ can be predicted theoretically. The genomic representation of the hybrid is  $ab'cc$ , of which the two c-genomes derived from both sides of the parents should appear as  $9_{II}$  while the re-



Fig. 34. A polar view of heterotypic metaphase of the microsporogenesis with 26 univalents in the  $F_1$  hybrid *B. carinata* ♀ × *Raphanus sativus* ♂. Ca. ×2000.

maining two ones, "a" and "b", ought to appear as  $18_I$  of which about 5 (the members of a-genome) show the tendency towards the occasional formation of trivalents with the gemini as observed in COF<sub>1</sub>-II (acc). The configuration should, therefore, be represented as

$$(0-5)_{III} + (9-4)_{II} + (18-13)_I.$$

The actual observation in the hybrid obtained confirms this theoretical assumption, though, in rare instances, the number of trisomes is noted here to come to 6 and the representation may be corrected as

$$(0-6)_{III} + (9-3)_{II} + (18-12)_I.$$

In their appearance *B. juncea* and *B. cernua* remind one always of the intermediate nature between the two monogenomic forms, *B. campestris* and *B. nigra*. The former two species, having been proved to have the same chromosomal constitution from the genetical and karyological point of view (MORINAGA, 1929; SASAOKA, 1930), possess 18 chromosomes as their gametic number which coincides with the sum of those of the latter two. It has been already pointed out by MORINAGA (1929) and SASAOKA (1930) that *B. juncea* (= *B. cernua*) which contains a-genome presents  $10_{II} + 8_I$  and  $10_{II} + 17_I$  at heterotypic metaphase of the microsporogenesis when crossed with 10-chromosomal species and with *B. napus* respectively. Further, FUKUSHIMA (1929) has reported that in the first division metaphase of the  $F_1$  hybrids *B. cernua* ♀ × *Raphanus sativus* ♂ there appear 27 scattered univalents showing neither allosyndetic nor autosyndetic union of chromosomes. MORINAGA has used the notation "b" to denote the undefined set of 8 chromosomes which composes the reduced chromosome complement of *B. juncea* and *B. cernua* together with the genome "a", so that, according to him, the genomic representation of the species is aabb. The members of b-genome have obviously no affinity towards those of "c", because the two genomes appear as 17 univalents in the meiosis of the  $F_1$  (aabc) *B. napus* ♀ × *B. juncea* ♂. The relation is quite similar to that between "b" and "c" seen in *carinata-Raphanus* hybrid, the former genome containing also 8 chromosomes. Although the author has failed in the hybridization between the two species, *juncea* and *nigra*, which resulted in only matroclinous offspring, the metaphasic



configuration in the  $F_1$  hybrid (abb'c) *B. juncea* ♀ × *B. carinata* ♂ may provide the necessary basis for the elucidation of the composite genome of *B. juncea*. In the named hybrid, as has already been described, the number of the bivalents varies from 8 to 16 with the number of univalents ranging from 19 to 3, i.e.

$$(8-16)_{II} + (19-3)_I.$$

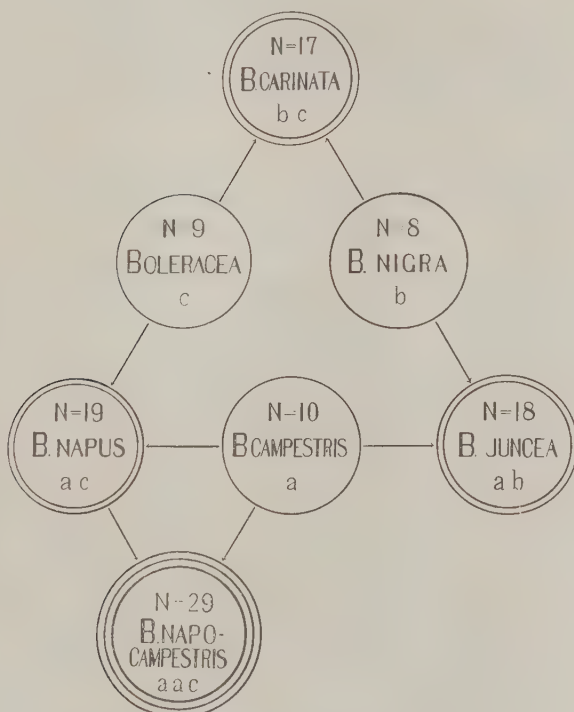


Fig. 35. Diagrammatic representation of the genomic relations among the species in *Brassica*.

Since it contains a- and c-genome contributed by *juncea* and *carinata* respectively,  $(0-8)_{II} + (19-3)_I$  should come out by the cooperation of the members of these in quite a similar manner as observed in  $COF_1-I$  (ac). It is, therefore, clear that the remaining 8 bivalents

which are constantly formed are due to the synapctic union occurring among the members of the other two genomes, "b" and "b' ". The fact suggests strongly that "b" is really identical to "b' " and allows us to conclude that *B. juncea* (*B. cernua*) is an allotetraploid whose reduced chromosome complement consists of "a" and "b' " (= "b").

As has been discussed the composite genomes of the species with higher chromosome number, i.e. those with 17, 18, and 19, are proved to be due to the collaboration of two of the three different sets of chromosomes found in the three monogenomic species, *B. campestris* (or allied species with 10 chromosomes), *B. nigra*, and *B. oleracea* (or allied species with 9 chromosomes). Their genomic relations are shown in the diagram (Fig. 35).

#### 10. The origin of the anomalous hybrids with extra set of chromosomes

As already stated, two of the  $F_1$  individuals,  $COF_1$ -II and  $COF_1$ -III, derived from the cross *B. campestris* ♀ × *B. oleracea* ♂, and  $CaOF_1$ -II-2 derived from that *B. carinata* ♀ × *B. oleracea* ♂ were proved to be the triploids and the tetraploid respectively. From the karyological evidences there can be no doubt that the extra set of chromosomes in  $COF_1$ -II and  $CaOF_1$ -II-2 came from the male and that in  $COF_1$ -III from the female side.

Similar cases of the formation of peculiar  $F_1$  individuals with extra number of chromosomes have been reported by several authors. BREMER (1923) obtained a triploid  $F_1$  hybrid ( $2n=136$ ) from the cross *Saccharum officinarum* ( $n=40$ ) ♀ × *S. spontaneum* ( $n=56$ ) ♂. From the genetical and karyological reasons he concluded that this can probably be due to a longitudinal fission of the *officinarum*-chromosomes during fertilization leaving those of *spontaneum* unsplit and giving rise to a zygote with 136 chromosomes. CRANE and DARLINGTON (1927) reported that they obtained a tetraploid individual ( $2n=28$ ) from a cross between diploid and tetraploid blackberry species, *Rubus rusticanus* ( $n=7$ ) ♀ × *R. thyrsinger* ( $n=14$ ) ♂, and two heptaploid individuals ( $2n=49$ ) from a cross between a hexaploid and a diploid raspberry, *Rubus* "Loganberry" ( $n=21$ ) ♀ × *R. idoeus* ( $n=7$ ) ♂. It is stated on the basis of genetical and karyological evidence, that they have resulted undoubtedly from the functioning of unreduced ova. A  $F_1$

hybrid with 60 chromosomes has arisen from the cross *Nicotiana Tabacum* ( $n=24$ ) ♀ × *N. sylvestris* ( $n=12$ ) ♂ (WEBBER, 1930, cf. DARLINGTON, 1932; SANSOME and PHILP, 1932). In the cross between diploid ( $n=8$ ) and tetraploid ( $n=16$ ) *Campanula persicifolia*, GAIRDNER and DARLINGTON (1931) obtained a tetraploid hybrid ( $n=16$ ). These were also reported to have been caused by the unreduced gametes on the female side.

Doubling on the paternal side has also been reported in four cases. EMERSON and BEADLE (1930) reported a tetraploid hybrid ( $2n=40$ ) derived from a cross *Euchlaena perennis* ( $n=20$ ) ♀ × *Zea mays* ( $n=10$ ) ♂. It was suggested that either the maize parent had contributed two sets of chromosomes or one maize set had doubled after fertilization. In a cross *Dianthus sinensis* (tetraploid,  $n=30$ ) ♀ × *D. Knappii* ( $n=15$ ) ♂ ANDERSSON and GAIRDNER (1931) obtained a fertile tetraploid ( $2n=60$ ) among the sterile sister  $F_1$ -plants. They concluded that a normal egg cell ( $n=30$ ) of *D. sinensis* was fertilized by a pollen grain of *D. Knappii* with the unreduced number, i.e. 30 instead of 15 chromosomes. A tetraploid *Primula sinensis* has arisen from a cross between a tetraploid (♀) and a diploid (♂) plant of this species which was explained by DARLINGTON (1931) also to be due to the unreduced sperm nucleus. KOSTOFF and KENDALL (1931) obtained in the cross between tetraploid (♀) and diploid (♂) *Petunia* also a considerable number of tetraploid  $F_1$ . Although they could not attain to a definite conclusion, two possible ways in which the tetraploids might have arisen were suggested: firstly they might have been caused by the triple fusion of the egg-nucleus of the tetraploid mother plant with both the generative and the vegetative nucleus from the pollen grain of the diploid father plant, and secondly they might have been due to the unreduced gamete produced on the male side similarly to the *Primula* above mentioned. It is, however, more probable that they were due to the second cause, since the father plant was observed to form dyad pollen grains when grafted on *Solanum nigrum* and pollen was often taken from flowers of shoots so grafted for pollinating the tetraploid plant.

Another case of chromosome increase has recently been reported by SHIMOTOMAI (1933) who crossed a diploid form of wild chrysanthemum, *Ch. japonicum* ( $2n=18$ ), always as the female parent, with other wild forms in higher polyploid state, viz., *Ch. morifolium* (6n), *Ch. Decaisneanum* (8n), and *Ch. marginatum* (10n). In each

case of these crosses the  $F_1$ -plants did not show the expected numbers of somatic chromosomes, 36, 45, and 54 which were the sums of the gametic numbers of the parents respectively, but 63, 72, and 81, i.e. always the expected numbers+27 extra chromosomes. From the morphological and karyological viewpoint he concluded that the facts are probably due to the repeated longitudinal splitting of the chromosomes of *japonicum* in the first cleavage of the zygotes.

To sum up, the extra set or sets of chromosomes found on each case are explained to be due either to an unreduced gamete on one side or to a longitudinal splitting of paternal or maternal set at the first cleavage of a zygote, though no definite experimental verifications are not at hand.

Before discussing the origin of the triploids obtained in the present case some important facts should be mentioned here. As has already been stated in the description of the hybridization experiment some matromorphic individuals were obtained, together with the true  $F_1$  hybrids in each cross. They were always fully fertile and bred true in later generations. From the reasons that the method of bud pollination was applied in our cross operations and that in *Brassica* no seeds were obtained without pollination, there is no doubt that the apomixis by which they might be produced was induced by the stimulus of the pollen of different species. Moreover, since no apomictic development of the secondary embryo-sac nuclei (apogamy) has hitherto been reported in *Brassica*, it will be natural and appropriate to consider that they originated from the egg cells. Further, as the microsporogenesis observed in each parental species was carried out quite regularly, any kind of irregularities resulting in the frequent formation of unreduced ova cannot easily be approved in the macrosporogenesis. It is, therefore, highly probable that they were caused by the parthenogenetic development of the normal haploid egg nuclei followed by the subsequent doubling of chromosomes in their earliest stage of cleavage.

NOGUCHI (1928) obtained in the cross *B. campestris* ♀ × *B. oleracea* ♂, only pure maternal offspring which bred true in later generations. The cytological examination has revealed that though one of the two *oleracea* male nuclei usually enters the egg cell of *campestris* and the other proceeds near to the polar nuclei, these never fuse together but each male nucleus disintegrates only after stimulating the apomictic development of the egg nucleus into an embryo. Although he made no reference to the chromosome number

of the maternal offspring, it might be safely concluded from the above mentioned facts that they were in diploid state, and the doubling occurred in the earliest cleavage stage. Quite a similar phenomenon was also reported by JØRGENSEN (1928) in the cross between *Solanum nigrum* ♀ and *S. luteum* ♂ where the *nigrum* egg cell developed by the presence of *luteum* sperm nucleus which afterwards disintegrated. In this case, however, occasionally both sperm nuclei were found inside the egg cell.

As to the origin of the triploids COF<sub>1</sub>-III which have one extra maternal set, and COF<sub>1</sub>-II and CaOF<sub>1</sub>-II-2, each of which has one extra paternal set, the author could not attain to a very definite conclusion, but it might perhaps be explained in the following way. In the egg cell of *B. campestris* which was stimulated to an apomictic development by the presence of the *oleracea* sperm nucleus, chromosome doubling has occurred in the first cleavage stage to form a diploid nucleus, then the latter, instead of disintegrating, might have occasionally fused with the former, so as to give rise to a triploid embryo carrying one extra maternal set. The extra paternal set found in COF<sub>1</sub>-II and CaOF<sub>1</sub>-II-2 might have been caused by the occasional triple fusion of the two *oleracea* sperm nuclei with the egg nuclei of *campestris* and of *oleracea*.

#### IV. Summary and conclusion

1. Karyological investigation of the F<sub>1</sub> hybrids obtained in various interspecific hybridizations in the genus *Brassica* are described mainly from the genome-analytical viewpoint with some remarks on the anomalous modes of fertilization leading to the formation of peculiar F<sub>1</sub> hybrids with extra set of chromosomes.

2. The gametic number of chromosomes of the parental species used in the crosses are as follows:

<i>B. nigra</i> KOCH. ....	8	<i>B. carinata</i> BRAUN ...	17
<i>B. oleracea</i> L. ....	9	<i>B. juncea</i> COSS .....	18
<i>B. campestris</i> L. ....	10	<i>B. napus</i> L. ....	19

3. The hybridization experiment comprises the following 7 crosses which have been made during five years since 1929 at Kônosu Farm of the Imperial Agricultural Experiment Station:



- i. *B. campestris* L. ♀ × *B. oleracea* L. ♂
- ii. *B. napus* L. ♀ × *B. oleracea* L. ♂
- iii. *B. napus* L. × *B. campestris* L.
- iv. *B. carinata* BRAUN ♀ × *B. oleracea* L. ♂
- v. *B. carinata* BRAUN ♀ × *B. nigra* KOCH ♂
- vi. *B. napus* L. ♀ × *B. carinata* BRAUN ♂
- vii. *B. juncea* COSS. ♀ × *B. carinata* BRAUN ♂

4. Varying degrees of interspecific incompatibility are noted in each case of the crosses. The hybridization between two different species is performed only in one direction where the one having higher number of chromosomes is taken for the female, except in the case, *napus* × *campestris*, where reciprocal crosses have given almost equal results, though the germination of F<sub>1</sub> seeds is always better when the higher-numbered species is taken for the female.

5. The F<sub>1</sub> hybrids obtained in the cross i, vi, and vii are of intermediate types between the parental forms, and the first of these is particularly remarkable as being suggestive of *B. napus* in every respect.

6. The 4 F<sub>1</sub> hybrids obtained in the cross *campestris* ♀ × *oleracea* ♂, viz. COF<sub>1</sub>-I, COF<sub>1</sub>-II, COF<sub>1</sub>-III, and COF<sub>1</sub>-VI, were proved to differ from each other in their chromosomal constitution. Only in COF<sub>1</sub>-I the expected zygotic number of chromosomes, 19, is observed. The other three, COF<sub>1</sub>-II, COF<sub>1</sub>-III, and COF<sub>1</sub>-IV, have 28, 29, and 38 chromosomes respectively, each possessing 9, 10, and 19 extra ones. The karyological evidences show that the two individuals, COF<sub>1</sub>-II and COF<sub>1</sub>-III, are the triploid hybrids, the former carrying an extra c (= *oleracea*)-genome and the latter an extra a (= *campestris*)-genome, thus being acc and aac respectively, and that COF<sub>1</sub>-IV is an allotetraploid or an amphidiploid possessing both a- and c-genome in duplicated state (aacc).

7. Varying degrees of partial fertility are also noted among three of them, while the individual COF<sub>1</sub>-IV is completely fertile.

8. Another peculiar F<sub>1</sub> hybrid, CaOF<sub>1</sub>-II-2, has arisen in the cross *carinata* ♀ × *oleracea* ♂ which possesses 35 somatic chromosomes instead of the expected number 26, containing 9 extra ones. Investigation of the metaphase configurations in the meiosis of the hybrid has revealed that the 9 extra chromosomes are identical to those which constitute the c-genome.

9. The reduction division carried out in the  $F_1$  hybrids are mostly of *Pilosella*-type, save those in the three, viz.  $COF_1$ -I,  $JCaF_1$ , and  $COF_1$ -IV. In the first of these it proceeds after *Triticum-Secale*-type, in the second the combination of *Pilosella*- and *Triticum-Secale*-type is observed, and in the third it differs scarcely from that of the pure 19-chromosomal species. The chromosome configurations observed at heterotypic metaphase in each of the  $F_1$  hybrids are summarised as follows:

$F_1$  *campestris* ♀ × *oleracea* ♂

$COF_1$ -I ( $2n=19$ )	.....	(0-8) <sub>II</sub> + (19-3) <sub>I</sub>
$COF_1$ -II ( $2n=28$ )	.....	(0-5) <sub>III</sub> + (9-4) <sub>II</sub> + (10-5) <sub>I</sub>
$COF_1$ -III ( $2n=29$ )	.....	10 <sub>II</sub> + 9 <sub>I</sub>
$COF_1$ -IV ( $2n=38$ )	.....	19 <sub>II</sub>

$F_1$  *napus* ♀ × *oleracea* ♂

NOF <sub>1</sub> -III ( $2n=28$ )	.....	(0-5) <sub>III</sub> + (9-4) <sub>II</sub> + (10-5) <sub>I</sub>
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$F_1$  *napus* ♀ × *campestris* ♂ and reciprocal

NCF <sub>1</sub> -I	} ( $2n=29$ )	..... 10 <sub>II</sub> + 9 <sub>I</sub>
NCF <sub>1</sub> -II		
CNF <sub>1</sub> -I		
CNF <sub>1</sub> -II		

$F_1$  *carinata* ♀ × *oleracea* ♂

CaOF <sub>1</sub> -I	} ( $2n=26$ )	..... 9 <sub>II</sub> + 8 <sub>I</sub>
CaOF <sub>1</sub> -II-1		
CaOF <sub>1</sub> -II-2 ( $2n=35$ )	.....	(9-5) <sub>III</sub> + (0-4) <sub>II</sub> + (8-12) <sub>I</sub>

$F_1$  *carinata* ♀ × *nigra* ♂

CaNiF <sub>1</sub> ( $2n=25$ )	.....	8 <sub>II</sub> + 9 <sub>I</sub>
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$F_1$  *napus* ♀ × *carinata* ♂

NCaF <sub>1</sub> ( $2n=36$ )	.....	(0-6) <sub>III</sub> + (9-3) <sub>II</sub> + (18-12) <sub>I</sub>
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$F_1$  *junceae* ♀ × *carinata* ♂

JCaF <sub>1</sub> -I	} ( $2n=35$ )	..... (8-16) <sub>II</sub> + (19-3) <sub>I</sub>
JCaF <sub>1</sub> -II		

10. From these metaphasic configurations, coupled with the reports of MORINAGA and others, it is concluded that the species with higher chromosome number, i.e. those with 19, 18, and 17, in *Brassica* are really the allotetraploids whose composite genomes are due to the collaboration of two of the three different ones found in

the three monogenomic species with 10, 9, and 8 chromosomes viz., monogenomic species

10-chromosomal species (*B. campestris* or its allied species) . . aa

8-chromosomal species (*B. nigra*) . . . . . bb

9-chromosomal species (*B. oleracea* and *B. alboglabra*) . . . . . cc

digenomic species

17-chromosomal species (*B. carinata*) . . . . . bbcc

18-chromosomal species (*B. juncea* and *B. cernua*) . . . . . aabb

19-chromosomal species (*B. napus*) . . . . . aacc.

11. A weak affinity is noted between the members of the two genomes, "a" and "c", which is displayed in remarkably manifold manner according to the ratio of the coexisting genomes. When "a": "c" = 1 : 1 (COF<sub>I</sub>-I), the varying number of gemini is formed, 8 being the highest; in the ratio of 1 : 2 (COF<sub>I</sub>-II), trisomic associations, ranging in number from 0 to 5, rarely 6, are formed; and when it is reversed to 2 : 1 (COF<sub>I</sub>-III), the gemini formed by the 2 "a" never associate with the member of "c", showing no trace of the affinity and leaving the latter as univalents.

12. Trisomic association is not perfect when the "c"-genome is confined in triple condition (CaOF<sub>I</sub>-II-2).

13. Dyad formation originating both from the omission of the first reduction division and the complete union of two daughter spindles is observed frequently in each of the F<sub>1</sub> hybrids.

14. The origin of the peculiar F<sub>1</sub> hybrids above mentioned is discussed to the effect that i) the triploid, COF<sub>I</sub>-II, and the tetraploid, CaOF<sub>I</sub>-II-2, can perhaps be due to the triple fusion of an egg of each mother plant with two sperm nuclei of *oleracea*, ii) the other triploid, COF<sub>I</sub>-III, to the occasional fusion of a sperm nucleus of *oleracea* with an egg of *campestris* which, by the stimulation of the former, has already undergone the first cleavage accompanying the doubling of chromosomes, and iii) the other tetraploid, COF<sub>I</sub>-IV, to the endoduplication occurring in the earliest cleavage stage of the zygote which is the result of fusion of two reduced gametes.

15. Among the F<sub>2</sub> progenies of COF<sub>I</sub>-I fertile individuals with 38 somatic chromosomes have arisen, which show 19 bivalents invariably formed at heterotypic metaphase of the microsporogenesis. Hence, the experimental formation of *B. napus* might have been performed in two possible ways, viz. through either somatic (COF<sub>I</sub>-IV) or gametic doubling in F<sub>1</sub>.

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### Explanation of plate V

Figs. a-f. Microphotographs showing the polar views of heterotypic metaphase in the microsporogenesis of parental species. ca.  $\times$  4100.

- a, *B. nigra* KOCH. ( $n=8$ ).
- b, *B. oleracea* L. var. *gemifera* ZENKER ( $n=9$ ), "Komoti-Kanran".
- c, *B. campestris* L. ( $n=10$ ), "Enuma-Zairai".
- d, *B. carinata* BRAUN var. *Harron* ( $n=17$ ), "Abyssinian Mustard".
- e, *B. juncea* COSS. ( $n=18$ ), "Kigarasi".
- f, *B. napus* L. var. *oleifera* DC. ( $n=19$ ), "Aduma".

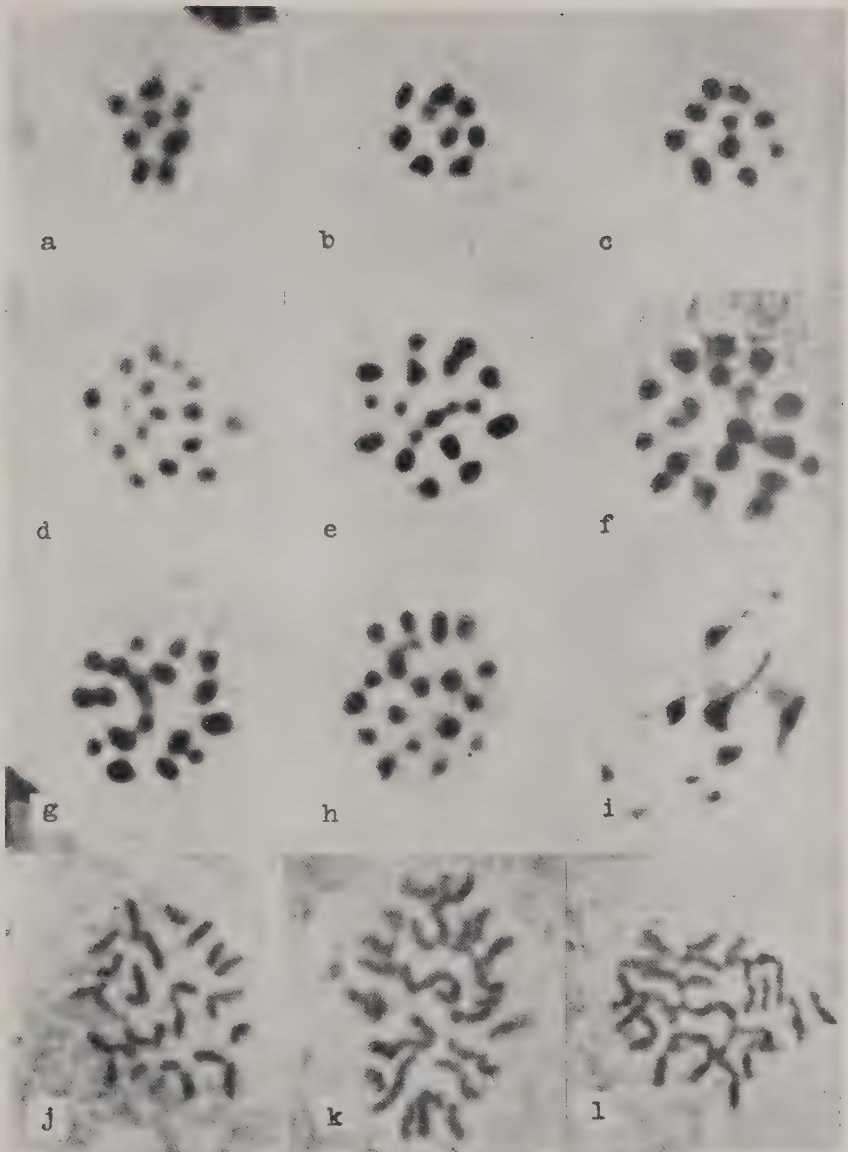
Figs. g and h. Polar views of heterotypic metaphase of experimentally formed *B. napus*. ca.  $\times$  4100.

- g, COF<sub>1</sub>-IV ( $n=19$ ).
- h, COF<sub>1</sub>-Ic-2 ( $n=19$ ).

Fig. i. Oblique view of heterotypic metaphase of CaOF<sub>1</sub>-II-2, the tetraploid F<sub>1</sub> hybrid (bccc) *carinata*  $\varnothing$   $\times$  *oleracea*  $\sigma$ , 5 of the hetero-chromosome like trivalents are seen. Cf. text-fig. 27e. ca.  $\times$  4100.

Figs. j-i. Metaphase of mitosis from the root-tip cells. ca.  $\times$  3000.

- j, COF<sub>1</sub>-II (2n=28), Cf. Text-fig. 12b.
- k, CaOF<sub>1</sub>-II-2 (2n=35), Cf. Text-fig. 25b.
- l, CaOF<sub>1</sub>-II-1 (2n=26), Cf. Text-fig. 25a.





# The genetics and cytology of certain cereals

## VII. Genetical significance of the c-chromosome in hexaploid *Avena* species<sup>(1)</sup>

By Ichizo NISHIYAMA

With 15 text-figures

(Received March 25, 1935)

### Introduction

Heterozygous fatuoids with 20 bivalents and the c-univalent were occasionally found in certain cultivated varieties of *Avena sativa* and *A. byzantina*<sup>(2)</sup>. From their monosomic inheritance it has been shown that the c-chromosome bears genes essential for normal chromosome pairing at meiosis and for the appearance of the cultivated characters of the grain (HUSKINS 1927, 1928, 1932, NISHIYAMA 1931, HUSKINS and HEARNE 1933). Later NISHIYAMA (1933a, b), after especially close observation, found that the long arm of the c-chromosome ( $s_1$ ) contributes to normal chromosome pairing and its short arm ( $s_2$ ) to the cultivated characters of the grain. Owing to meiotic abnormalities, asynaptic 40-chromosome fatuoids which lack a pair of c-chromosomes were almost completely sterile.

From genetical studies on interspecific hybrids made by previous authors it can be assumed that the c-chromosome in other oat species also may be connected with the appearance of certain grain characters. However, its bearing on the chromosome pairing at meiosis and on the inheritance of hairy grains is not yet clear.

(1) Contributions from the Laboratory of Genetics, Biological Institute, Kyoto Imperial University, No. 58.

(2) Heterozygous fatuoids with  $20n+c$  reported in my previous papers were obtained from the oat varieties Aurora, Banner (*A. sativa*) and Kanota (*A. byzantina*) (NISHIYAMA 1931 and 1933 a, b).



The present study was attempted in order to ascertain the cytogenetical role of the c-chromosome in two species, *Avena fatua* and *A. sterilis*, in comparison with that of *A. sativa* and *A. byzantina*.

## Material and methods

In this study my observation was chiefly confined to the inheritance of monosomic plants possessing twenty bivalents and one c-chromosome from *A. fatua* or *A. sterilis*. These monosomics were readily obtained from the crosses *A. fatua* and *A. sterilis*  $\times$  heterozygous fatuoids with  $20_{II}+c$ , which were found in the Aurora variety of *A. sativa* and were used in my previous studies on fatuoid oats (NISHIYAMA 1931, 1933 a, b). I obtained these  $F_1$  hybrids in 1932 and their  $F_2$  segregates were cultivated in 1934.

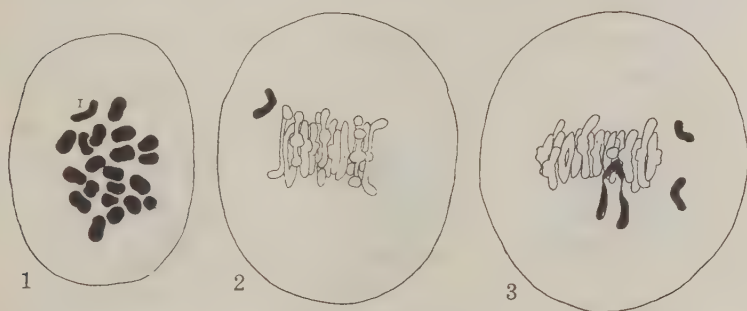
Cytological observations were made on fresh and fixed material. Flower buds were first treated with CARNOY's fluid for a few minutes and then fixed in FLEMMING's medium fixative or LA COUR's fluid 2Bd for 24 hours. All permanent preparations were made from the fixed material by the paraffin method. Sections were cut 12–20 microns thick and stained with HEIDENHAIN's iron alum h matoxylin, or gentian violet by NEWTON's method. All figures, except Figs. 9–11, were drawn from permanent preparations in  $\times 2450$  and reduced to  $\times 2000$  in reproduction. Figs. 9–11 were drawn from smeared preparations made by BELLING's method in  $\times 2000$  and reduced to  $\times 1200$  in reproduction.

## I. Cytological observations

### 1. Cytology of $F_1$ hybrids

In both crosses, heterozygous fatuoids ( $20_{II}+c$ )  $\text{♀} \times A. fatua$  ( $20_{II}+cc$ )  $\text{♂}$  and *A. sterilis* ( $20_{II}+cc$ )  $\text{♂}$ , as was expected,  $F_1$  hybrids were found to possess 41 or 42 chromosomes. The 41-chromosome hybrids usually showed twenty bivalents and one univalent at the first metaphase of PMC. The univalent always showed a submedian constriction. Its shape and size closely resembled that of the c-chromosome from *A. sativa* (Figs. 1–2). The normal chromosome conjugation was occasionally disturbed by lack of pairing between some of the homologous chromosomes and also by the multiple associa-

tion of partially homologous chromosomes. I sometimes found 2-3 univalents and, in an extreme case, 6 univalents per PMC. A quadruple association was seldom formed and usually showed a ring-shaped form. Its four components all appeared to be of similar size, but clearly smaller than the c-chromosome. Furthermore, the chromosome conjugation  $1_{III} + 18_{II} + 2_I$  was rarely observed, as shown in Fig. 3. Judging from their size and shape, one of the two univalents seemed to be a component separated from the ring complex, and the other, the c-chromosome. In the later stages of meiosis, the behavior of the chromosomes, especially of univalents, was similar to that of heterozygous fatuoids with  $20_{II} + c$  (NISHIYAMA 1931, 1933 a, b).



Figs. 1-3, first metaphase in PMC. Fig. 1,  $F_1$  heterozygous fatuoids ( $2n = 41$ )  $\times$  *A. fatua*, showing  $20_{II} + 1_I$ , polar view. Fig. 2,  $F_1$  heterozygous fatuoids ( $2n = 41$ )  $\times$  *A. sterilis* with  $20_{II} + 1_I$ , side view. Fig. 3, the same, showing  $1_{III} + 2_I$ .

In 42-chromosome hybrids 21 bivalents were clearly counted but in rare cases some aberrant chromosome matings were observed, as in 41-chromosome plants. Such abnormalities were often or rarely found in interspecific oat hybrids and even in pure cultivated oats (NISHIYAMA 1929, 1931, PHILP 1933).

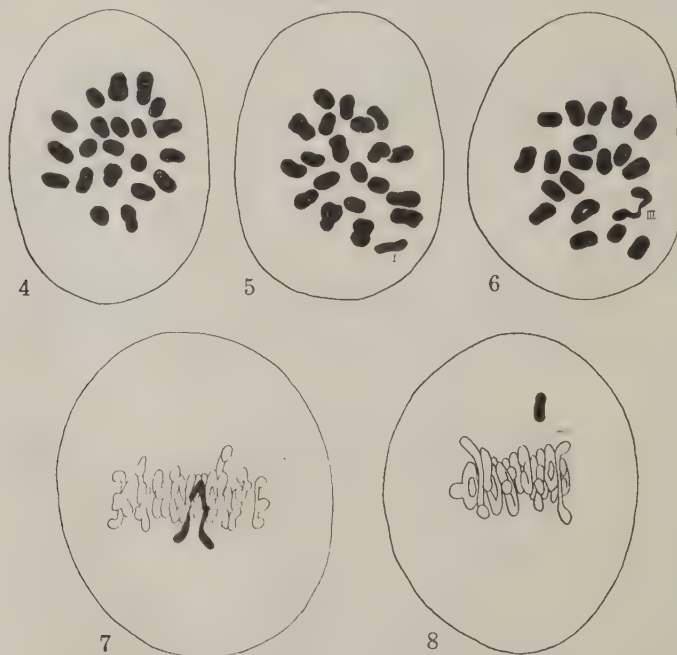
## 2. Cytology of $F_2$ segregates

Fifty and fifty-nine kernels from  $F_1$  hybrids with  $20_{II} + c$  were sown from two crosses, between heterozygous fatuoids ( $20_{II} + c$ ) and *A. fatua* and *A. sterilis* respectively. The majority of them germinated (78-92% germination) and grew to maturity. Their chromosome numbers were counted at the first metaphase and were

found to be 40, 41 or 42 in somatic number, as given in the following table.

TABLE 1  
Frequency of  $F_2$  segregates having 40-42 chromosomes in the  
progeny of hybrids with 41 chromosomes ( $20_{II}+c$ )

Chromosome number	40		41		42	Total
	$40_I$	$19_{II}+c+1_I$	$20_{II}+c$	$19_{II}+cc+1_I$	$20_{II}+cc$	
Het. fatuoids ( $20_{II}+c$ ) $\times A. fatua$	12	0	32	0	1	45
Het. fatuoids ( $20_{II}+c$ ) $\times A. sterilis$	19	1	15	1	0	36

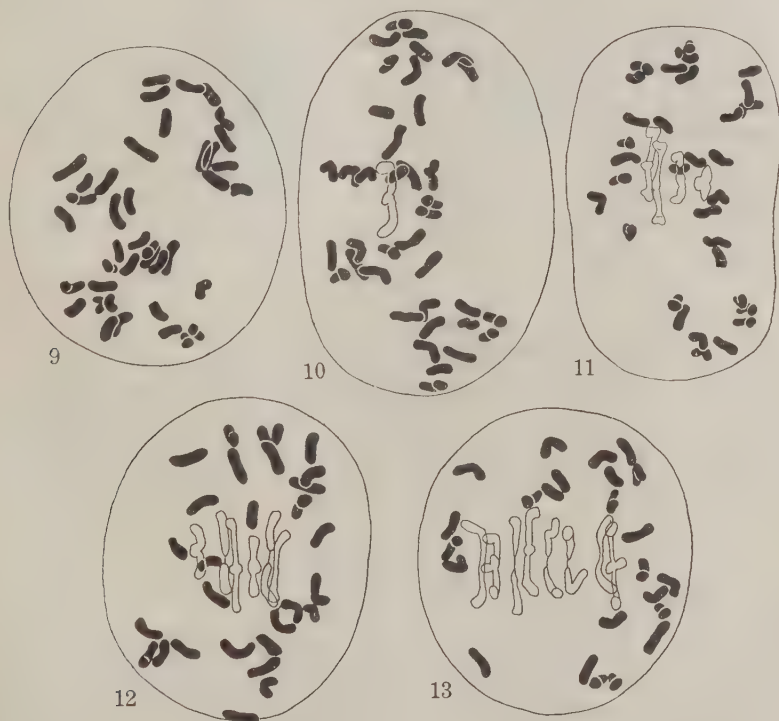


Figs. 4-8, chromosomes at the first metaphase in PMC. Fig. 4,  $F_2$  segregate from heterozygous fatuoids ( $2n=41$ )  $\times A. fatua$ , showing  $21_{II}$ . Fig. 5, the same with  $20_{II}+1_I$ . Fig. 6,  $1_{III}+19_{II}$ . Fig. 7, the same from a side view. Fig. 8, first metaphase, showing a small univalent.

From Table 1 it can be seen that the segregation ratios in  $F_2$  approach those of the b-type fatuoids in series II where homozygous ( $40_I$ ) and heterozygous fatuoids ( $20_{II}+c$ ) were obtained in a ratio 1:1+, with a few normals ( $21_{II}$ ). This may be explained by the fact that their parental plants possessed the same chromosome constitution  $20_{II}+c$ .

The mode of chromosome pairing at meiosis was observed with special attention in each of these 81  $F_2$  segregates. The results will be briefly mentioned in the following.

Only one 42-chromosome plant was obtained. It usually showed 21 bivalents (Fig. 4). With one exception all of the 41-chromosome



Figs. 9-13, meiotic chromosomes in PMC of asynaptic 40-chromosome plants. Figs. 9,  $40_I$ . Fig. 10,  $1_{II}+38_I$ . Fig. 11,  $4_{II}+32_I$ . Fig. 12,  $6_{II}+28_I$ . Fig. 13,  $8_{II}+24_I$ .

plants gave 20 bivalents and 1 univalent (c-chromosome) (Fig. 5). The one exception referred to was a plant grown from the offspring of heterozygous fatuoids ( $20_{II} + c$ )  $\times$  *A. sterilis* and its chromosome conjugation was usually  $20_{II} + 1_I$  but often  $1_{III} + 19_{II}$ . And it must not be overlooked that the univalent was smaller than the c-chromosome (Figs. 6-8). From the cytological and morphological observations, as given later, it is likely that the chromosome constitution of this plant is  $19_{II} + cc + 1_I$ . Besides characteristic chromosome pairing, most of the  $F_2$  segregates with 41 or 42 chromosomes sometimes showed a multiple association or failure in pairing between some of the homologous chromosomes, as in  $F_1$ .

With the exception of the one case, all of the 40 chromosome plants showed a very irregular meiotic behavior of the chromosomes. That is, most of the chromosomes were not paired and were irregularly scattered through the whole spindle at the first metaphase. Figs. 9-13 illustrate some pollen mother-cells showing different numbers of bivalents and univalents. Among the paired chromosomes a trivalent was found in very rare cases. In some 40 chromosome segregates I observed the frequency of pollen mother-cells having different numbers of paired chromosomes. The results are given in Table 2.

TABLE 2

Frequency of PMC showing different numbers of paired chromosomes  
in asynaptic plants with 40 chromosomes

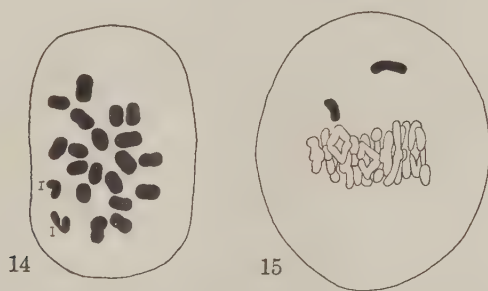
Plant No.	No. of paired chromosomes										Total	
	0	1	2	3	4	5	6	7	8	9		10
34-329- 1	8	12	13	9	3							45
„ -11	13	13	34	31	16	6	5	1				119
34-330- 4	5	12	6	9	3	3						38
„ -21 (a)	20	22	41	31	21	10	5	1				151
„ (b)	13	15	32	17	13	4	2					96
„ -25	5	19	28	27	25	7	1	1	1			114
„ -26	1	0	2	2	9	7	8	6	5	1	1	42
Total	65	93	156	126	90	37	21	9	6	1	1 <sup>a</sup>	605

34-329 ..... Het. fatuoids ( $2n = 41$ )  $\times$  *A. fatua*  $F_2$

34-330 ..... „  $\times$  *A. sterilis*  $F_2$



From this table it can be seen that asynaptic plants show a wide range in regard to the number of paired chromosomes in different pollen mother-cells. Owing to incomplete pairing, the chromosome behavior was very abnormal throughout meiosis and non-functional gametes were usually produced. These karyological irregularities are quite similar to those in asynaptic homozygous fatuoids (see NISHIYAMA 1931, 1933 a, b). The exceptional plant ( $2n=40$ ) referred to above showed an unusual combination of chromosomes, namely  $19_{II} + 2_I$  at the first metaphase (Figs. 14 and 15). These



Figs. 14-15, first metaphase of an unexpected  $F_2$  plant with  $19_{II} + 2_I$ .

two univalents differ in size: from the mode of chromosome conjugation and the morphological characters of this plant the larger one seems to be the c-chromosome. The occurrence of such aberrant segregates might be due to the occasional irregularities of chromosome conjugation at meiosis in the 41-chromosome hybrids.

## II. Morphological observations

### 1. $F_1$ hybrids

$F_1$  hybrids differed not only in chromosome number,  $2n$  being 41 or 42, but also in some characters of the grain. Table 3 shows the relation between chromosome number and some of the grain characters of  $F_1$  hybrids and their parents in the cross heterozygous fatuoids ( $20_{II} + c$ )  $\times$  *A. sterilis*. As will be discussed later, except the pubescence on the back of the grain, the grain characters of

*A. sterilis* (the *sterilis* complex) are in contrast with the so-called cultivated characters in *A. sativa* or *A. byzantina*.

TABLE 3  
Some grain characters of *A. sterilis*, heterozygous fatuoids  
( $2n = 41$ ) and their  $F_1$  hybrids

Character	Het. fatuoids <sup>(1)</sup> $2n = 41$	<i>A. sterilis</i> <sup>(2)</sup> $2n = 42$	$F_1$ hybrids	
			$2n = 41$	$2n = 42$
Awn	Usually present on first grain, weakly developed	Present on both first and second grains, but absent on third one	Nearly the same as <i>A. sterilis</i>	Present only on first grain, weakly developed
Basilar connection of grains	Solidified	Articulated on first grain, but solidified on the others	The same as <i>A. sterilis</i>	Solidified
Basal hairs	Absent on each grain	Present on first and second grain, but absent on the others, numerous, bushy, long	Nearly the same as <i>A. sterilis</i>	Present only on first grain, scarce, long
Hairs on rachilla	Absent on each grain	Present on first grain, but absent on the others <sup>(3)</sup> , numerous, bushy long	Nearly the same as <i>A. sterilis</i>	Absent on each grain
Hairs on the back of grains	Absent on each grain	Dense hairs present on both first and second grains, but absent on the others	Nearly the same as <i>A. sterilis</i>	Medium degree of pubescence

(1) In homozygous fatuoids each grain shows an articulated base, remarkably developed awns and short hairs on the rachilla and base. All of these characters are strongly linked and called "fatuoid characters". Normal oats represent "cultivated characters", i.e., solidified base, awnlessness and no hairs on the rachilla and base.

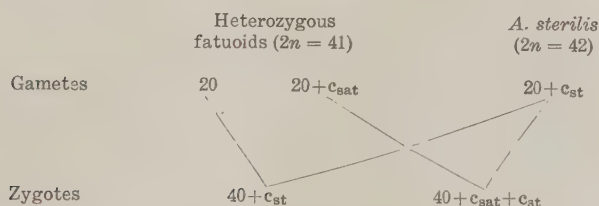
(2) Every grain of the homozygous fatuoids sheds from its axis when mature, whereas in *A. sterilis* first grains (or spikelets) shed freely while the others strongly persist to their rachillae. This is the outstanding character by which these plants are distinguished.

(3) The second grain closely persists to the rachilla of the first so that it is difficult to distinguish the rachilla from the base of the second grain.

All of the 41-chromosome hybrids were characterized by grains with the *sterilis* complex but the 42-chromosome plants set grains similar to those of the heterozygous fatuoids.

Heterozygous fatuoids with  $20_{II} + c_{sat}$  (c-chromosome of *A. sativa*) give two kinds of gametes possessing 20 and  $20 + c_{sat}$ , whereas *A. sterilis* has only one kind of gametes with  $20 + c_{st}$  (c-chromosome of *A. sterilis*). Accordingly, if a cross is made between these plants, 41-chromosome hybrids always contain only one c-chromosome,  $c_{st}$ , and 42-chromosome plants two c-chromosomes,  $c_{sat}$  and  $c_{st}$ , as shown in Scheme I. It is also shown from this scheme that with regard to

SCHEME I



40 chromosomes both hybrids have the same chromosome constitution. From these morphological and cytological facts it is concluded that the *sterilis* complex is chiefly controlled by  $c_{st}$  and it is partially recessive to the *sativa* complex.

In the cross where *A. fatua* was used as parent, I obtained only one  $F_1$  hybrid of which the chromosome number was counted to be 41 ( $20_{II} + c_{fat}$ ). Its grain characters were very similar to those of *A. fatua*.

## 2. $F_2$ segregates of 41-chromosome ( $20_{II} + c$ ) hybrids

It has already been mentioned that  $F_1$  hybrids ( $20_{II} + c_{st}$ ) from heterozygous fatuoids  $\times$  *A. sterilis* gave 40- and 41-chromosome segregates and that they showed 4 different chromosome constitutions, including 2 unexpected ones. The occurrence of 42-chromosome plants is also to be expected but they have not yet been obtained, surely due to the small amount of material studied.

The grain characters of all asynaptic 40-chromosome plants are always found to represent the fatuoid complex, whereas those of the

41-chromosome ( $20_{II} + c_{st}$ ) segregates are of the *sterilis* type. Thus we can see a close relationship between the presence of the  $c_{st}$ -chromosome and the occurrence of the *sterilis* complex of the grain. The grain characters of a plant with an exceptional chromosome constitution,  $19_{II} + 2_I$ , could not be clearly observed, as fully developed panicles were not obtained, the young panicles being disorganized before heading. But they probably had the *sterilis* complex. The other unexpected plant with  $20_{II}$  and a small univalent showed the same grain characters as *A. sterilis*. From these morphological characteristics it is readily deduced that these two exceptional segregates may have had one or a pair of  $c_{st}$ -chromosomes. This assumption is further supported by the cytological observation, as previously stated.

When *A. fatua* was the parent of the cross, all of the expected  $F_2$  segregates with 40, 41 and 42 chromosomes were obtained as illustrated in Table 2. However, each of them were similar in appearance, showing the fatuoid or *fatua* complex. Of course some different grades in development of the grain characters were found, but it was difficult to classify them. These facts suggest that the genes in question borne on the  $c_{fat}$ -chromosome are similar or hypostatic to those for the fatuoid complex in the b-chromosome.

In short, from the inheritance of the c-chromosome of *A. fatua* and *A. sterilis* it has clearly been shown that this chromosome plays a similar genetical role to that of the c-chromosome of *A. sativa* or *A. byzantina*. That is, normal chromosome pairing and the specific grain characters are chiefly controlled by these chromosomes.

I have further made some observations on the inheritance of the grain color and hairs on the back of the grain. As shown in Table 3 all of the  $F_1$  hybrids with 41 chromosomes have hairy grains. In  $F_2$  there was found a considerable variation in the amount of hairs. However an attempt was made to classify them into 4 classes: dense (both first and second grains show dense hairs), medium (first grain has medium-dense hairs and second grain sparse hairs), a few (first grain has a few hairs and second grain a very few or no hairs), and no hairs (both grains are hairless) (Table 4). It is to be noted that in both crosses the completely glabrous grains are confined to the 40-chromosome segregates although some of them, of course, have hairy grains. On the contrary, most of the plants with 41 and 42 chromosomes have shown dense or medium-dense hairs, while some or a few had sparse pubescence. From these facts it is suggest-

ed that some independent genes which may be cumulative in their effect are connected with the occurrence of dense hairs. And it is also safely assumed that the c-chromosome from *A. fatua* or *A. sterilis* brings about at least a few hairs on the back of both grains.

TABLE 4  
Relation between chromosome number and hairs  
on the back of the grain

Progeny of het. fatuoids $\times$ <i>A. sterilis</i>	No. of segregates showing grains with				Total
	dense hairs	medium hairs	a few hairs	no hairs	
2n = 40	0	15	2	2	19
2n = 41	13	1	1	0	15
Progeny of het. fatuoids $\times$ <i>A. fatua</i>	0	0	3	7	10
	12	14	6	0	32
	1	0	0	0	1

From their genetical studies SURFACE (1916) and PHILP (1933) stated that hairs on the back of second grains are governed by a recessive gene, which is only effective if first grains are hairy, and is completely linked with the *fatua* complex. BARTLETT (1916), however, published another view, *i.e.*, that hairs on both grains may be controlled by one and the same gene but its effect is incompletely inhibited on first grains and completely on second grains, the inhibitor being linked with the genes for the *sativa* complex of the grain. The genetical results are fairly well explained by either of these assumptions. Against these authors' hypotheses, however, the present investigation has represented direct evidence to the effect that the  $c_{fat}$  and  $c_{st}$ -chromosome must carry a gene, or two closely linked genes, for a few hairs on the back of the first and second grains. In that case, assuming that in the heterozygous condition a few hairs effected by the c-chromosome are incompletely suppressed on first grains and completely so on second ones, the genetical results in question are more practically understood. As suggested in my last paper, the assumption that genes show different intensity in their



effect on first and second grains appears to be generally applicable to the inheritance of grain characters of oats where certain characters occur on first grains but partially or completely are suppressed on second grains, as often observed by many workers.

Sterile grains are, in general, not characteristically colored when mature. Accordingly, asynaptic 40-chromosome plants could not be used for the genetical investigation on the grain color. Out of 32  $F_2$  segregates ( $2n=41$ ) from the cross heterozygous fatuoids ( $20_{II}+c$ )  $\times$  *A. fatua*, 8 showed yellowish-gray, and 24 dark brown grains, clearly representing the monogenic segregation ratio. Except two cases showing medium-dense hairs, all the yellowish-gray grains possessed a few hairs on the back, whereas each of the 24 dark brown plants had grains with dense or medium-dense hairs. Any attempt to explain the result remains a matter of speculation, but a probability of a linkage between brown color and pubescence on the back of the grain may be suggested, as already found by SURFACE (1916), LOVE and CRAIG (1918), FLORELL (1931), PHILP (1933) and AAMODT, JOHNSON and MANSON (1934). There is no doubt that the presence of this pubescence is controlled by a gene carried by some other chromosome than the c-chromosome. Accordingly it is generally stated that the hairs on the back of the grain of plants with 41 or 42 chromosomes at least are governed either by one or two factors which are independent of each other.

When *A. sterilis* is used as parent the inheritance of the grain color appears to be somewhat complicated. That is, 9 plants showed dark brown grain like *A. sterilis*, 3 had brown, 1 light brown, and 2, dark gray grains. Owing to the small number of plants observed, we cannot elucidate the details of the genetical behavior. However, it is certain that the grain color is generally inherited independently of the grain characters under consideration.

## Discussion

The genus *Avena* comprises a large number of hexaploid species differing in many characters. Their grain-character complex constitutes an important taxonomic mark of distinction. The genetical analysis of these characters has often been attempted by many workers in interspecific oat hybrids. According to them, in the cross *A. fatua*  $\times$  *sativa*, the *sativa* complex is partially dominant to the *fatua*

complex and  $F_2$  shows the monohybrid segregation ratio, these complexes being controlled by a group of closely linked genes (SURFACE 1916, LOVE and FRASER 1917, LOVE and CRAIG 1918<sup>(1)</sup>, TSCHERMAK 1918, 1929<sup>(2)</sup> CRÉPIN 1928, NISHIYAMA 1929, PHILP 1933 and AAMODT, JOHNSON and MANSON 1934)<sup>(3)</sup>. Similarly in other crosses, *A. fatua*  $\times$  *sterilis* (TSCHERMAK 1929, FLORELL 1931), *A. sterilis*  $\times$  *sativa* (SHEGALOV<sup>(4)</sup>, TSCHERMAK 1929<sup>(5)</sup>, FLORELL 1931), *A. byzantina*  $\times$  *sativa* (FRASER 1919) and *A. fatua*  $\times$  *byzantina* (FLORELL 1931), the difference of the grain characters is usually due to one complex of genes closely linked. A similar phenomenon was repeatedly observed in the intervarietal crosses, fatuoids  $\times$  normals in *A. sativa* or *A. byzantina*.

According to HUSKINS (1927, 1928) and NISHIYAMA (1931, 1933a, b and the present investigation) asynaptic 40-chromosome oat plants which lack a pair of c-chromosomes generally show the fatuoid complex of grain characters. However, if they recover the normal chromosome constitution their grains represent the same type as that of a plant from which the c-chromosomes are derived. From this fact it is certain that the specific grain characters of each species are chiefly affected by its c-chromosome. Here we can say that the genetical and cytological results agree very closely.

NISHIYAMA (1929) made some interspecific hybrids, *A. sativa*  $\times$  *fatua*, *A. sterilis*  $\times$  *fatua* and *A. sativa*  $\times$  *byzantina*, and described their morphological characters. The grain characters of these  $F_1$  hybrids closely approached those of the parents mentioned first in each cross. Similar results were also obtained by many workers, as described above. From these results the following conclusion may be stated. The *sativa* complex is partially dominant to both *fatua* and *sterilis* complexes, and the *sterilis* complex is partially dominant to the *fatua* complex. The genes for one complex differ to some extent from those for another and the complexes behave as multiple allelomorphs.

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(1) Cited from EMME (1931) and PHILP (1933).

(2) and (5) TSCHERMAK, however, explained his results by two alternative interpretations—(1) by the assumption of bifactorial inheritance scheme or (2) the assumption of association-dissociation difference between wild and cultivated oats.

(3) According to EMME (1931) MITROFANOVA, ZHEGALOV, FEDOROVA *etc.* also got the same result.

(4) Cited from HUSKINS (1927).

Besides the grain characters, the c-chromosome generally controls chromosome pairing at meiosis and also the production of a few hairs versus hairlessness on the back of both first and second grains.

PHILP (1933) extensively reviewed the genetical studies of the grain characters in interspecific oat hybrids and discussed the chromosome constitution for the complex of the grain characters in some of the species. That is, adopting the chromosome formula  $\frac{ABC}{ABC}$  given by HUSKINS (1928) for *A. sativa*, he designated *A. fatua* and *A. sterilis* by the modified ones  $\frac{Ac'c}{Ac'c}$  and  $\frac{ABc^s}{ABc^s}$  respectively. In these formulae the symbols A and c<sup>s</sup> show two non-homologous chromosomes but both of them carry genes for the *sterilis* complex, c and c' being connected with the *fatua* and fatuoid complex respectively, and the latter corresponding to B. On B and C are located genes for the fatuoid and *sativa* complex respectively, as assumed by HUSKINS (1927, 1928).

As often stated, it is remarkable that, in general, asynaptic 40-chromosome oat plants invariably show nearly the same appearance of the grain, exhibiting the fatuoid complex. From this fact it is very plausible that they all have a pair of chromosomes, e.g., b-chromosomes<sup>(1)</sup>, carrying the fatuoid genes. At present we cannot find any difference between the b-chromosomes from different species, although PHILP (1933) especially designated this chromosome in *A. fatua* by another symbol c'.

In the progeny of *A. sativa* itself, or *sativa-fatua* hybrids, aberrant plants having some of the *sterilis* characters seldom occurred (STANTON, COFFMAN and WIEBE 1926, JONES 1930 and PHILP 1933). PHILP (1933) stated that the principal cause of their origin might be the genic unbalance induced by the excess of A-chromosomes which

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(1) It is temporarily assumed that the b-chromosome (or B after HUSKINS 1928) effects the fatuoid complex, although we have as yet no direct evidence. The *fatua* and fatuoid complex have been often used with the same meaning. It has now become necessary to distinguish them strictly, because the fatuoid complex is effected by the b-chromosomes and the *fatua* complex by the c-chromosomes. However it is uncertain whether the grain characters of *A. fatua* are directly due to its b or c-chromosomes, or to either of them. But it is certain that the c-chromosome bears recessive genes to those for the *sativa* complex. Accordingly the fatuoid complex is unable to constitute a multiple allelomorphous series with the *fatua*, *sterilis* and *sativa* complexes.

bear the *sterilis* complex. Owing to his hypothesis it seems probable that the excess of chromosomes,  $2c$  and  $2c'$ , in *A. fatua* which effect the *fatua* or fatuoid complex prevents the occurrence of the *sterilis* complex due to a pair of A-chromosomes. However there is a serious obstacle to his assumption. It is the fact that grains of all plants without c-chromosomes are of the fatuoid complex but never of the *sterilis* complex, whereas from many genetical studies the *sterilis* complex is certainly dominant or epistatic over the *fatua* or fatuoid complex. JONES (1930) had another opinion, *i.e.*, that these aberrants occurred by gene mutation in the c-chromosome, but his assumption appears to the writer to be unsatisfactory.

I have found some steriloids in the offspring of triploid hybrids between *A. barbata*  $\times$  *strigosa* (NISHIYAMA 1934). These aberrants always segregated steriloid and *barbata* types, but in no case was there found a constant aberrant. This and other facts are in favour of the assumption that their origin is chiefly due to the cooperation of the two following phenomena: (1) different intensity of the genes in their effect on first and second grains and (2) disturbed genic balance caused by aberrant combinations of chromosomes carrying genes for articulated or solidified bases of both grains (NISHIYAMA 1934). Such a mechanism seems to be one of the probable causes for the origin of *sterilis*-like forms or sub-fatuoids in hexaploid oats. As we now have no detailed genetical studies of these aberrants a further discussion on the mode of their origin and their genetical constitution can hardly be attempted.

### Summary

The present paper deals chiefly with the monosomic inheritance of plants with twenty bivalents and one c-chromosome from *A. fatua* or *A. sterilis*. From this study it may be concluded that the c-chromosome of these species controls their specific grain characters, their chromosome pairing at meiosis and causes a few hairs on the back of the first and second grains. Its genetical role without doubt corresponds to that of the c-chromosome from *A. sativa* or *A. bysantina*.

The writer wishes to express his sincere appreciation to Prof. Dr. H. KIHARA and Dr. F. LILIENFELD for kind suggestions and much helpful criticism.

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## Abstracts Nos. 1-110

(Referring to the principal papers in Botany and allied subjects which have appeared in Japan during July-December 1933)

**1. Mitosen im Antheridium von *Sargassum confusum* AG.** Kôgorô ABE. (Sc. Rpts., Tôhoku Imp. Univ. 4th. Ser. **8**, 1933, 259-262, 1 Taf.).

Im Antheridium von *Sargassum confusum* erfährt der dort im Anfang befindliche einzige Zellkern eine heterotypische Mitose, wobei 32 Chromosomen leicht zu zählen sind. Keine Zentrosomen wurden dabei gefunden. Die sog. "chromophilous spherules" wurden neben dem Nukleolus aufgefunden, welche bisher in einigen, wie *Dictyota* und *Padina*, gesehen wurden. Die sukzessiven Teilungen der Kerne folgen und nach der sechsten entstehen 64 freie Kerne, welche durch zytoplasmatische Scheidewände zu 4 Spermatumterzellen getrennt werden.

**2. On the syngamy of some Myxomycetes.** Seiji ABE. (Sc. Rpts. Tokyo Bunrika Daigaku, Sec. B, Div. 2, No. 18, 1934, 193-202, 1 fig.-group).

The culture experiments of *Fuligo septica*, *Erionema aureum*, *Didymium nigripes*, *Physarum crateriforme*, and *Stemonitis fusca* from the spore to the plasmodium were made in distilled water on a slide, certain bacteria or yeasts being added as nutriments. The swarm-cells, each with a flagellum, which are produced from the germinating spores, come to fusion: two come into contact, then one of them ( $\sigma$ ) which becomes diminished in size is entirely absorbed by the other ( $\varphi$ ) to form together an amoeboid zygote with no flagellum. The nuclear fusion of two swarm-cells was observed in fixed preparations. It is evident that these swarm-cells represent the planogametes. Between them no difference in pH was discernible, but the difference of their oxydo-reduction potential, as detected by certain staining reactions, was observed, the female being lower than the male in this respect. By studying the resistance against the cation ( $\text{Cu}^+$ ) and anion ( $\text{CN}^-$ ) the female was found to be positively, and the male negatively charged. The plasmodium is formed by the fusion of amoeboid zygotes.

**3. On the systematic anatomy of the leaves of some Japanese Carices (II)-(IV).** (Japanese). Shigeo AKIYAMA. (Bot. Mag. Tôkyô **47**, 1933, 532-550, 17 fig.-groups; 767-797, 17 fig.-groups.; 863-881, 10 fig.-groups).

Continuation of the author's first paper (cf. Japan. Jour. Bot. **6**, (95), No. 336). Part II refers to the leaf anatomy of 10 species of *Carex*. Part III gives firstly the key for the identification of 17 species, belonging to the section Rhomboidales based on leaf anatomy. Then follows the special part, where the leaf anatomy of each species is described. Part IV refers to 10 species of the section Tumidae, and the same treatment is made as in Part III.

(2)

**4. Lichenologische Notizen I-II.** (Japanisch m. deuts. Zfg. u. latein. Diagnosen). Yasuhiko ASAHINA. (Jour. Japan. Bot. **9**, 1933, 64-67, 4 Abb.; 138-141, 5 Abb.).

Die folgenden neuen Lichenenarten wurden mit Hilfe der Textabbildungen lateinisch beschrieben: *Dermatocarpon myogiense* und *Heterocarpon simodense*. *Pertusaria epileia* NYL., *Perforaria cucurbitula* (MONT.) MÜLLER ARG. und *Perforaria epilcoides* WAIN. wurden unter *Perforaria cucurbitula* (MONT.) MÜLLER ARG. zusammengefasst. *Verrucaria porinopsis* NYL. soll *Perforaria porinopsis* (NYL.) Y. ASAHINA sein.

**5. On the occurrence of haploid plants in *Triticum monococcum*.** (Japanese). Yoshiwo CHIZAKI. (Proc. Crop Sc. Soc. Japan **5**, 1933, 267-270).

The author has found a haploid plant of *Triticum monococcum* in field in summer 1932 (cf. Japan. Jour. Bot. **6**, (70), No. 245), whose stature, ear length, leaf length and breadth are smaller than in the normal plant. The pollen mother-cell nucleus is distinguished by possessing 7 independent univalents, of which the mode of distribution towards the two poles is variable. As to the cause of the formation of this plant three hypotheses are proposed by the author.

**6. Studien über die Physiologie der schwefeloxydierenden Bakterien.** Yoshikadzu EMOTO. (Bot. Mag. Tōkyō **47**, 1933, 405-422, 495-531, 567-588, 14 Textabb.).

Der vorliegende Aufsatz bezieht sich hauptsächlich auf die Ernährungsphysiologie der von dem Verf. isolierten schwefeloxydierenden Bakterienarten, *Thiobacillus therrmitans*, *lobatus*, *crenatus* und *umbonatus*. Optimum Temperatur für *T. therrmitans* ist 28°. Wenn die von dem Verf. isolierten Bakterien bei 40-50° 2 Stunden leben können, starben sie bei 60-70° binnen wenigen Minuten. Die ultravioletten Strahlen verursachen ihren Tod. Sie sind als fakultative Aeroben aufzufassen. Optimum pH=5,4. Die Schwefeloxydation wird natürlich durch verschiedene Substanzen befördert oder gehemmt. Die Förderung geschieht z.B. durch die anorganischen Säuren (HCl, HNO<sub>3</sub>, H<sub>2</sub>SO<sub>4</sub> usw.), und die Verhinderung z.B. durch eine kleine Menge von Stärke (0,25%). Bei CO<sub>2</sub>-freier Luft geschieht keine Schwefeloxydation. Das Cytochrom wurde aufgefunden, was zum ersten Male bei den autotrophen Bakterien geschehen ist. Das Oxydoreduktionspotential, wie mit den Indikatoren gemessen, war rH=23,1 oder mehr. Bezüglich zahlreichen anderen Einzelheiten vgl. das Original.

**7. Eine neue Varietät von *Ceratomyxa fruticulosa* MACBRIDE.** Yoshikadzu EMOTO. (Proc. Imp. Acad. **9**, 1933, 416-417, 6 Textabb.).

Eine neue vom Verf. aufgefundene Varietät von *Ceratomyxa fruticulosa* wird beschrieben. Ebenso wird die Entwicklung der Sporophoren eingehend geschildert. Diese neue Varietät *descendens* wird von den typischen Art dadurch ausgezeichnet, dass 1. die Plasmodien flach sind, 2. zylindrische Fortsätze sich direkt aus denselben entwickeln, 3. der basale Teil der Sporophoren sich nicht abwärts senkt, und 4. polygonale plattenförmige Stückchen ausgebildet sind.

**8. Cyto-genetic studies on the wild and cultivated Manchurian soy beans.** Yasona FUKUDA. (Japan. Jour. Bot. **6**, 1933, 489-506, 1 pl. and 7 text-figs.).

**9. Transmission of the virus through the eggs of an insect vector.** Teikichi FUKUSHI. (Proc. Imp. Acad. **9**, 1933, 457-460).

The relation which exists between the dwarf disease of rice plants and the insect vector, the leafhopper *Nephotettix apicalis*, has been known long since in Japan. The following experiments of the author have shown that the virus carried by the insects are transmitted to their offspring through the eggs. A pair of male and female insects, both or either one, were confined together with a young healthy rice plant in a glass tube and transferred every day to a new healthy plant. When after some days the nymphs emerge from the eggs deposited by the above female, they were immediately transferred to a new healthy plant. In such experiments, when both parents or simply the female are infective, the offspring are as the rule infective, while when the male only is infective and the female uninfected, the offspring were never found to be infective.

**10. Karyologische Studien an Paris und Trillium.** Kazuo GOTOH. (Japan. Jour. Gen. **8**, 1933, 197-203, 19 Textabb.).

Früher (vgl. Japan. Jour. Bot. **5**, (32), Nr. 100) hat der Verf. zusammen mit STOW über die Zahl und Gestalt der Chromosomen von *Trillium* und *Paris* die Resultate ihrer Untersuchungen veröffentlicht. Danach ist bei diesen zwei Gattungen die Grundzahl der Chromosomen 5 statt 6, wie es nach verschiedenen Autoren der Fall sein soll. Der Verf. hat dabetreffend eine amerikanische Art, *T. sessile* untersucht und seine frühere Angabe über die japanischen Arten völlig bestätigen können, woraus er schliesst, dass die anderweitigen Angaben, wonach die Grundzahl bei *Trillium* 6 sein soll, auf dem Irrtum beruht. Das Vorhandensein der dreierlei Gestalt der Chromosomen stimmt bei japanischen und amerikanischen *Trillium*-Arten ganz zueinander überein.

**11. A preliminary note on cytological studies of Oryza.** Kazuo GOTOH and Eiji OKURA. (Jour. Soc. Trop. Agric. **5**, 1933, 363-364, 1 pl.).

The somatic chromosome number of the following wild species of *Oryza* was determined: *O. cubensis* EKMAN (from Cuba) 24, *O. latifolia* DESV. (from Cuba) 48, *O. sp.* (from Formosa, local name Oniine) 24.

**12. Wachstumsverhältnisse der Keimorgane von verschiedenen Gramineen im Dunkel und bei Belichtung mit besonderer Berücksichtigung ihrer systematischen Stellung.** Hideo HAMADA. (Mem. Coll. Sc., Kyoto Imp. Univ. Ser. B, **9**-1933, 71-128, 37 Textabb.).

Der Verf. hat das Wachstumsverhältnis von Mesokotyl, Koleoptyle und Primärblatt bei einer Anzahl von Gramineen untersucht, und zwar im Dunkel sowie im Lichte. Es ist natürlich kaum möglich alle diese Ergebnisse erschöpfend mitzuteilen und einige Beispiele davon können hier erwähnt werden. Bei einer Sippe von *Oryza*



*sativa* (Namens Asahi) ist die Schlusslänge des Mesokotyls im Dunkel 3,9 mm und im Lichte 0,9 mm. und das Hemmungsprozent beträgt 77, während bei einer anderen Sippe, "Riz flottant" aus den Tropen die Schlusslänge im Dunkel und Lichte 34,9 bzw. 7 mm. beträgt (Hemmungsprozent 83). Die Hordeae haben im allgemeinen fast kein Mesokotyl und sein Platz wird von der Koleoptyle eingenommen, deren Länge unter den Hordeae (ausgenommen *Avena*) am grössten ist.

Der Verf. hat das Wachstum von Mesokotyl, Koleoptyle und Primärblatt bei verschiedenen Gramineen wie folgt zusammengefasst:

I. Kein Mesokotyl und grösste Streckung von Koleoptyle wie Primärblatt (Hordeae); II. mittelmässige Wachstum von Mesokotyl und diesem etwas nachstehendes Wachstum von zwei anderen Keimorganen (Oryzeae, Phleae, Festuceae, Agrostideae, Chlorideae und Avenaeae) und III. riesiges Wachstum vom Mesokotyl und sehr geringes Wachstum von zwei anderen Keimorganen (Paniceae, Andropogoneae und Maydeae). Die Wachstumsverhältnisse dieser dreierlei Keimorgane kann als für den systematischen Zweck verwendet werden.

**13. Chromosome studies in diploid and triploid forms of *Disporum sessile*.** Nobumi HASEGAWA. (Japan. Jour. Gen. 9, 1933, 9-14, 15 text-figs).

The diploid form of *Disporum sessile* has 16 somatic chromosomes. Its meiosis, as observed in pollen mother-cells, is quite regular. In the triploid form with 24 somatic chromosomes 8 trivalents can be seen in the first metaphase. Later three elements of each trivalent conjugate end to end, which reminds of the autotriploidy, though in some cases a univalent and a bivalent will be seen. The elements of the trivalent are irregularly distributed towards the two poles, and consequently the chromosome number of pollen tetrads is variable. Triploid plants are sterile. The author thinks that the triploid plant was formed by the fusion of a normal diploid and a haploid gamete, and that the plant should be an autotriploid.

**14. Inoculation experiments with heteroecious species of the Japanese rust fungi. I.** Naohide HIRATSUKA. (Bot. Mag. Tôkyô, 47, 1933, 710-714).

By means of inoculation experiments the author has ascertained the heteroecious connection between the aecidia of fungi on various plants (*Ranunculus*, *Plantago*, *Rumex*, *Lycopus*, *Clematis*, *Adoxa*, *Clethra*) and various *Uromyces* and *Puccinia* species.

**15. On the oxydase and the dehydrase in phytopathogenic fungi.** Yoshikatsu HIRAYAMA. (Proc. Imp. Acad. 9, 1933, 639-642).

The occurrence of oxydase in pathogenic fungi was often announced till now, but that of dehydrase very rarely. The author has studied the occurrence of indophenolase (oxydase) and succinodehydrase in many species of Japanese pathogenic fungi. The experimental results are shown in two tables, including 25 species in all, belonging to the genera *Gibberella*, *Ophiobolus*, *Corticium*, *Colletotrichum*, *Pestalotzia*, *Alternaria*, *Piricularia*, *Fusarium*, *Sclerotium*, *Fomes*, *Polyporus* and *Lenzites*. One of the author's results is that the oxydase occurs not only in "Korrosionspilze" (as stated by BAVENDAMM), but also in the "Destruktionspilze". In some species neither indophenolase nor succinodehydrase could be detected.

**16. On the overwintering of *Peronoplasmodium cubensis* (B. et C.) CLINTON.** Makoto HIURA and Shigehiro KAWADA. (Japan. Jour. Bot. **6**, 1933, 507-513, 1 pl.).

**17. Homothallism in *Sphaerotheca fuliginea* (SCHLECHT.) POLLACCI.** Yasu HOMMA. (Proc. Imp. Acad. **9**, 1933, 186-187, 1 fig.).

The single spore inoculation with the conidium of *Sphaerotheca fuliginea* was made on *Taraxacum ceratophorum*. The formation of antheridial and ascogonial hyphae was observed on a single mycelium produced in consequence of the above inoculation. The homothallism of the fungus under question was thus duly proved.

**18. On two new species of *Calamagrostis* from the prov. Simotuke.** Masaji HONDA. (With Japanese résumé). (Jour. Japan. Bot. **9**, 35-38, 2 figs.).

*Calamagrostis scaberrima* and *C. Sekimotoi* are new and described.

**19. A new species of *Anaphalis*.** (Japanese). Masaji HONDA. (Jour. Japan. Bot. **9**, 279-280, 1 fig.).

*Anaphalis viscosissima* sp. nov. with its Latin diagnosis and figures.

**20. Notulae ad leguminosarum ex Asiae orientalis V.** (With Japanese résumé). Takahide HOSOKAWA. (Jour. Soc. Trop. Agric. **5**, 1933, 287-290).

The following new species are described: *Lespedeza formosensis* and *Vicia Ohwiana*.

**21. Ein Beispiel des Zwischengeschlechtes bei *Aucuba japonica*.** (Japanisch). Sigeo HOSONO. (Japan. Jour. Gen. **9**, 1933, 277).

Ein Individuum von *Aucuba japonica*, wurde gefunden, wobei man die Blüten in verschiedenen Übergangsstadien vom männlichen nach dem weiblichen Status sieht. Das Genom besteht dabei aus 33+1f Chromosomen im Gegensatz zu den normalen Fall, wo es aus 32 besteht. Nach der Ansicht Verfs. könnte solches Genom dadurch entstanden sein, dass eine Gamete, welche wegen des Nichttrennens bei der Kernteilung mit einem überflüssigen Chromosom und einem Fragment desselben ausgestattet ist, mit einem normalen vereinigt hatte.

**22. On the double staining method by gentiana-violet-eosin for the differential colouration of hyphae of pathogenic fungi and host tissue.** (Japanese). Suehiko IKATA. (Jour. Plant Prot. **19**, 1932, 809-813).

The microtome section made of the materials fixed with the CARNOY's or FLEMING's solution are treated after the usual procedure as follows: after staining by 1% gentiana-violet solution in 50% alcohol (5-10 min.) they are washed with 50% alcohol, stained by 1% eosin solution in 50% alcohol (30-60 min.), treated by carbol-turpentine (or better by the mixture 2 turpentine +1 cedar oil +2 crystallized carbolie acid), treated by xylol and then imbedded in Canada-balsam. By this method, for instance, the cell-walls of the host tissue are stained violet, its chlorophyll grains and fine granules red, while the hyphae become stained intensely brilliant red.

**23. Studies on red spot disease (chocolate spot disease) of *Vicia faba*.** (Japanese) Suehiko IKATA. (Rpt. of the Agric. Exp. Sta. Okayamaken, extra No. 38, 1933, 28 pp., 5 pls. and 5 text-figs.).

The disease of *Vicia faba*, whose symptom is the production of red brownish circular spots on leaves and of similar streaks on stems, was generally considered to be due to the action of a certain pathogenic bacterium. The author has however ascertained that it is really due to the pathogenic action of *Botrytis fabae* sp. nov. somewhat resembling *B. cinerea*. It is very probable that the so-called streak disease or chocolate spot disease in England is not of one sort, and contains among others the disease under question. *B. fabae* is very virulent towards *Vicia faba*, but quite indifferent towards others, such as "Saatwicken", *Pisum*, *Phaseolus*, *Astragalus*, alfalfa. In summer sclerotia are formed on stems and petioles, and from November to the next March it continually produces conidia. It penetrates through the epidermis, but not through stomata. Conidia are never produced directly on the hyphae, but always on sclerotia.

**24. Studies on the putrefaction disease of edible lilies.** (Japanese). Suehiko IKATA and Takesi HITOMI. (Rpt. of the Agric. Exp. Sta. Okayamaken, extra No. 39, 1933, 16 pp. and 5 pl.).

In a certain part of the Prefecture of Okayama lilies are widely cultivated, whose edible bulbs are much esteemed by the Japanese. The disease begins with the production of spots on upper surface of leaves, and finally leads to the death of the whole plant. The causal fungus is *Botrytis elliptica* (BERK.) COOKE. Basing on the infection experiments the authors come to the conclusion that the infection takes place on the surfaces of leaves. It may occur on their upper surface with no wounds at all, so that the fungus may clearly directly penetrate through the cuticle. The results of artificial infection has however indicated that it will spread more rapidly on the lower than on the upper surface; this is due not only to the greater thickness of cuticle and cell-wall of the upper epidermal cell than the lower, but also to the fact that the stomatal infection may also take place on the lower surface, the upper being destitute of stomata.

**25. On two new species of Tuberaeae.** Sanshi IMAI. (Proc. Imp. Acad. 9, 1933, 182-185, 10 figs.).

Two new species are described, viz. *Genea sphaeroides* and *Terfezia gigantea*.

**26. Gloeostereae S. ITO et IMAI, a new tribe of Thelophoraceae.** (With Japanese résumé). Sanshi IMAI. (Trans. Sapporo Nat. Hist. Soc., 13, 1933, 9-11, 3 figs.).

A new gelatinous fungus found growing on the rotten wood of *Acer pictum* and *Ulmus japonica* in a certain part of Hokkaidô is a new species, *Gloeostereum incarnatum* S. ITO et IMAI. Not only does it belong to a new genus, but it should be placed among a new tribe Gloeosterieae of the Thelophoraceae.

**27. Red algae in the Gulf of Oryoro and neighbouring sea.** (Japanese). Kwan'iti INAGAKI. (Rpt. Sta. Algal Res., Hokkaidô Imp. Univ. No. 2, 1933, 1-77, 81 text-figs.).

This paper consists chiefly of the description of 69 species of algae belonging to various families of Rhodophyceae. A key for the determination of the genera is appended at the end of the paper.

**28. Meiotic mitosis in *Hordeum sativum*.** (With Japanese résumé). Choyo INOUE. (Bull. Miyazaki Coll. Agric. and For. 5, 1933, 77-96, 3 pls.).

The author has studied in detail the meiosis of pollen mother-cells in *Hordeum sativum*, and has especially laid emphasis on the fact that the nucleolus supplies the material for the chromosome formation. For instance, in the interkinesis as well as tetrad stage the chromatin reticulum is connected at several points with the nucleolus, but in prophase the spirem which is connected with the nucleolus at a single point makes up a bundle. This connection is lost afterwards, but in the second prophase it is recovered, and the nucleolar material gradually passes over into the chromosome now in development, while in the second telophase the just opposite process occurs, i.e. the transfer of chromatin material from the chromosome to the nucleolus. At the end of pachytene stage the chromatin becomes hardly stainable, which constitutes the so-called achromatene stage. The chromosome number (haploid) in *Hordeum* is 7.

**29. *Nuntia ad Filices japonicae* (I).** Hiroshi ITÔ. (Jour. Japan. Bot. 9, 54-59, 9 figs.).

*Dryopteris inuyamensis*, *D. rhomboido-ovata*, and *D. indusiata* are new species and described.

**30. The diagnosis of the pollen of forest-trees.** Tadao JIMBO. (Sc. Rpts., Tôhoku Imp. Univ. 8, 1933, 287-296, 2 pls.).

For the pollen-analytical studies of our peat the preliminary investigation of the pollen of our living plants is necessary, whence the purpose of the study as stated in the title of this paper.

The fossil pollen found in a peat is generally empty and consists only of the exine, after protoplasm and the intine had decayed away. The author has treated living pollen by HCl in order to make it similar to that found in peat. The plants considered in this paper include several species from 9 families (Taxaceae, Cephalotaxaceae, Pinaceae, Taxodiaceae, Cupressaceae, Betulaceae, Ulmaceae, Tiliaceae, Fagaceae and Salicaceae), and for the pollen of each species the diagnosis is given.

**31. A contribution to the knowledge of regeneration in higher plants.** Kinzirô KAKESITA. (Jour. Fac. Agric. Hokkaidô Imp. Univ. 35, 1933, 1-100, 14 text-figs.).

The author has induced the regeneration in *Bryophyllum calycinum* and *B. crenatum* even in the leaves attached to the stems, which consists in the formation of new roots and shoots in the notches. The methods were the warm-bath treatment,



and the confinement within H- or N-gas for a certain time. According to the author's view such treatment will induce the anaerobic respiration, and its products act as stimulants for the regeneration. In fact the author could induce this process by the injection into stems and leaves of certain products of anaerobic respiration, especially acetaldehyde and ethyl alcohol. Further, the author could ascertain the accumulation or formation of acetaldehyde, alcohol and organic acids in the attached leaves subjected to the above treatments. (Cf. also Japan. Jour. Bot. **4**, p. 47 ff.)

**32. Über die Gametophyten einiger Laminariaceen.** (Japanisch). Tiyoiti KANDA. (Rpt. Sta. Algal Res., Hokkaidô Imp. Univ. No. **1**, 1933, 18-39, 2 Taf. u. 18 Textabb.).

Die Beobachtungen über den Generationswechsel wurden an *Laminaria japonica*, *Arthrothamnus bifidus* und *Costaria Turneri* ausgeführt, und zwar mittelst der künstlichen Kultur. Am ausführlichsten konnte die erste Pflanze studiert werden. Danach hat der wie gewöhnlich zweigeisselige Schwärmer keinen Augenfleck, und der daraus entstandene männliche Gametophyt kann aus nur wenigen oder zahlreichen Zellen zusammengesetzt sein, und in letzteren Falle ist er sehr reichlich verästelt. Das Antheridium ist immer unilokular und der Verf. konnte bei seiner Kultur das Heraustreten der kugeligen männlichen Gameten aus demselben beobachten. Der weibliche Gametophyt besteht aus wenigen Zellen, ja er kann nur einzellig sein, in welchem Falle diese einzige Zelle das Oogon sein wird. Eine Eizelle wird daraus herausgefördert, woraus die Befruchtung wahrscheinlich sofort geschehen kann, wenn der Verf. diesen Vorgang nicht beobachten konnte. Bei der Keimung sind die Rhizoiden reichlich produziert.

Die Entwicklung von *Arthrothamnus bifidus* ähnelt derselben von *Laminaria japonica*, wenn dabei die Untersuchung nicht so ausführlich hergestellt werden konnte, wie bei der letzteren.

*Costaria Turneri*, welche ebensowenig wie *Arthrothamnus* sehr ausführlich studiert werden konnte, unterscheidet sich beträchtlich von zwei anderen Arten in der Wachstumsweise des kugeligen Teiles, welcher bei der Keimung nächst dem Keimschlauch produziert wird: während bei zwei ersteren dieser Teil hauptsächlich in der Dicke wächst, er bei *Costaria* vorwiegend in der Länge zunimmt.

**33. New or noteworthy trees from Micronesia IV.** Ryôzô KANEHIRA. (Bot. Mag. Tôkyô **47**, 1933, 669-680).

Continuation of the author's former papers (cf. Japan. Jour. Bot. **6**, (69), No. 240).

The plants enumerated include the species of *Helicia*, *Polyalthia*, *Horsfieldia*, *Myristica*, *Aglaia*, *Cleistanthus*, *Gomphandra*, *Elaeocarpus*, *Sterculia*, *Garcinia*, *Eugenia*, *Boerlagiodendron*, *Northiopsis*, *Manilkara*, *Randolphia*, *Cerbera*, *Cyrtandra*, *Psychotria*, *Bikkia*. Almost all species are those newly named by the author.

**34. Flora micronesica.** (Japanese). Ryôzô KANEHIRA. (Publ. by Scuth Sea Bureau under the Japanese Mandate, 1933, 468 pp. text, 37 pp. index, 21 pls., 211 text-figs.).



This book is written by the author who has several times travelled various islands of Micronesia under the Japanese mandate, and made there extensive collections of plants.

The book is divided into three parts.

Part I which is entitled a general sketch of the flora of Micronesia treats first of all of its geography and the history of its botanical survey (Chapter I). In Chapter II (Kinds and distribution of plants) it is shown that the Micronesian plants hitherto recognized belong in all to 137 families, 594 genera and 1085 species, of which 340 species and the following 5 genera are endemic, viz. *Bentinekiopsis*, *Glubriopsis*, *Guamia*, *Ponapea*, and *Northirpsis*. 267 species (30,7%) are of the Indo-Malayan type, 234 (26,9%) of the Philippine, 34 (8,5%) of New Guinean and Moluccanan, 93 (10,8%) of Australian. The plant zones are classified into mangroves, coral-reef forests, sea coast forests, mountain forests, and culture land (Chapter III). Chapter IV contains the description of useful plants, etc.

Part II which forms the chief bulk of the book is devoted to the description of each species of trees and shrubs in Micronesia, beginning with the Cycadaceae and ending with the Goodeniaceae, 347 in all, very often with illustrations.

Part III is a list of plants of Micronesia, either ligneous or herbaceous, beginning with the Marattiaceae and ending with the Compositae. The distribution of each species is indicated.

**35. On the triploidy of *Crocus sativus* L. and its high sterility.** Kôtarô KARASAWA. (Japan. Jour. Gen. 9, 1933, 6-8, 6 text-figs.).

*Crocus sativus* is known as a highly sterile plant. The karyological examination of its root-tip cells has shown it to be a triploid plant with  $n=8$ . The formation of eight trivalents show it to be an autotriploid plant. Irregular meiosis leads to the formation of unequal tetrads, triads, dyads, and supernumerary microspores. The germination experiments of pollen grains has shown that half of them does not germinate, and even the germinated ones will not be effective on account of their incomplete genom.

**36. Crossing experiments in certain cereals with special reference to different compatibility between the reciprocal crosses.** Yoshiwo KATAYAMA. (Mem. Coll. Agric., Kyoto Imp. Univ. No. 27, 1933, 75 pp. and 29 text-figs.).

The author has performed the experiments on the species and genus crosses in *Triticum*, *Aegilops*, *Aegilotriticum*, *Oryza*, *Avena* and *Secale*.

Among various facts observed by him we may cite here chiefly the difference of different crosses concerning the setting of grains and their germination. To cite one instance in the cross *Aegilops ventricosa* ♀ × *A. durum* ♂ the setting of grains is good, but their germination was bad, while in the reciprocal cross the grains are badly set, but they germinate well. This is due to the fact that in the former combination though many eggs conceived, their development (also that of endosperm) was slow and incomplete and in the latter the eggs rarely conceived but they as well the endosperm developed much more rapidly.

The setting as well as the germination of grains are not necessary in correlation with the fact whether the female is lower or higher in chromosome number than the male, and even in some cases where both parents contain the same number of chromosomes, the difference in the effects of reciprocal crosses is observed.

On the basis of all his observations the author thinks that the difference in the grain setting and germination between reciprocal crosses is due to both qualitative and quantitative relations of the parental genomes, the former chiefly depending upon the qualitative and the latter as well as the seed development upon both. Further from the phylogenetic standpoint the relation between the genomes and the two processes under question is chiefly of the quantitative nature, and the remoter the parents, the more influential the qualitative difference.

**37. Spodograms of leaves in wheat.** (Japanese with English résumé). Huzio KATÔ. (Bull. Miyazaki Coll. Agric. & For. No. 5, 1933, 29-50, 8 figs.).

The spodograms of eight species of *Triticum*, viz. *T. Spelta*, *turgidum*, *durum*, *dicoccum*, *monococcum*, *polonicum*, *compactum* and *vulgare* were made. Each of them is described in detail with figures, and then follows a key for the determination of these wheat species according to their respective spodograms. The distinguishing marks are the shape and size of stomata, quartziferous cells, setiform hairs and epidermal cells.

**38. On the vegetation of Isl. Mang-tao, South Manchuria.** (Japanese). Masao KITAGAWA. (Jour. Japan. Bot. 9, 1933, 103-120, 9 figs.).

After the account of the author's excursion in the small island Mang-tao a table of plants collected there (134 in number) is given. The following new species are described, viz. *Brachypodium manshuricum*, *Phragmites hirsuta* and *Aster mang-taoensis*.

**39. A new Iris from South Manchuria.** (Japanese). Masao KITAGAWA. (Jour. Japan. Bot. 9, 1933, 246-250, 2 figs.).

*Iris Kobayashii* is described with figures.

**40. Compositae novae japonicae (VI).** (With Japanese résumé). Siro KITAMURA. (Acta Phytotax. et Geobot. 2, 1933, 171-188).

The following new species are described among others: *Artemisia araneosa*, *A. liukiensis*, *Aster lucens*, *Gynura formosana*, *Leontopodium spatulatum*, *Petasites formosanus*, *P. liukiensis*, *Saussurea Muramatsui*, *Taraxacum Arakii*, *T. ceratolepis*, *T. micranthum*, *T. quelpaertense*, *T. yetrofuense*.

**41. Taraxacum novum japonicum (I).** Hideo KOIDZUMI. (Jour. Japan. Bot. 9, 1933, 349-364).

36 new species of *Taraxacum* from various parts of Japan are described.

**42. Vergleich der täglichen Veränderungen des Gewichtes und Pulvervolumen der Trockensubstanz in Blättern zum Beweis der Eignung der KÖKETSUSchen Pulvermethode.** Riichiro Kôketsu, Teru FUJITA und Kazue HANDA. (Proc. Imp. Acad. 9, 1933, 419-421).

Die Blätter verschiedener Pflanzen wurden vielfach an einem hellen Tage gesammelt und dabei wurde die tägliche Veränderung des Trockengewichtes der Trockensubstanz sowie das Volumen des nach der KÔKETSUSchen Methode gemachten Pulvers derselben verglichen bestimmt, wobei die Bestimmungsergebnisse zuerst durch die Werte pro-Einheit-Gewicht der Asche oder der Zellulose-Gehalt im Blatte angegeben worden sind. Es hat sich dabei erwiesen, dass die Änderungen sowohl des Trockengewichtes als auch des Pulvervolumen gewöhnlich eine gleiche Neigung haben und doch die Veränderung des letzteren meistens klein ist als die der ersteren. Woraus die Verf. schliessen, dass wenn wir die tägliche Veränderung des Stoffgehaltes oder Funktionsgrades zahlenmässig ausdrücken wollen, die Werte bezogen auf die Einheit Volumen des Gewebepulvers viel empfehlenswerter als die auf die Einheit Trockengewichtes bezogenen sind.

**43. Über die Verteilung der elektrischen Potentiale an der Wurzel von *Vicia faba*.** (Japanisch). SInnosuke KOSUGE. (Bot. Mag., Tôkyô **47**, 1933, 589-601, 640-656, 49 Textabb.).

Es wird gezeigt, dass man mittels der eigens konstruierten unpolarsierbaren Elektroden, unter Anwendung des empfindlichen Galvanometers oder des Quadrantenelektrometers, an zwei beliebigen Punkten der Keimwurzel von *Vicia faba* charakteristische Potentialdifferenzen nachweisen kann. Die ermittelten Werte erreichen bisweilen 60 M. V.

Diese Potentialdifferenzen verteilen sich über die unverletzten Wurzel wie folgt: die Streckungszone ist stets am positivsten; das Meristem (Wurzelspitze) ist gegen die Streckungszone negativ, aber gegen die Wurzelhaube und gegen die Wurzelteile, wo die Zellstreckung schon vollendet ist, positiv.

Diese sich zwischen zwei beliebigen Stellen der Wurzel vorfindende Potentialdifferenz wird durch die Einwirkung solcher Atmungsgifte, wie z. B. Chloroform, Äther, Toluol oder Zyanwasserstoff beträchtlich herabgesetzt.

Wenn man der Wurzel einen schwachen elektrischen Strom appliziert, nimmt diese Potentialdifferenz, je nachdem die Stromrichtung auf- oder abwärts ist, ab bzw. zu. Man kann diese Erscheinung mit der Auf- bzw. Entladung einer galvanischen Zelle vergleichen.

Die mechanischen und chemischen Verletzungen verursachen starke negative Schwankungen.

Wie bei anderen Objekten kann man auch bei *Vicia*-Wurzel den sogenannten „Geoelektrischen Effekt“ nicht nur bei Horizontallage, sondern auch bei Inversstellung der Wurzel feststellen. Die Beeinflussung der natürlichen Potentialverteilung an der Wurzel durch den geoelektrischen Effekt wurde experimentell näher begründet.

Verf.

**44. *Alabastra diversa* II.** Fumio MAEKAWA. (Bot. Mag. Tôkyô **47**, 1933, 613-618, 3 figs.).

A key for the determination of *Celtis* species of Eastern Asia is given. Of various species, of which the diagnosis is given, *Hugeria incisa* is the new species.

**45. Beiträge zur Kenntnis der Flora von SüdJapan.** Genkei MASAMUNE. (Trans. Nat. Hist. Soc. Formosa **23**, 1933, 204-210).

23 Arten sind aufgezählt, von denen die folgenden zum erstenmale veröffentlicht und diagnostiziert sind: *Chimaphila taiwaniana*, *C. Fukuyamai*, *Photinia Kudoii*, *Asarum yakusimense*, *Lecanorchis Ohwi*, *Cryptostylus taiwaniana*, *Rhynchospora Umemurae* MAK. *yakusimensis* var. nov.

**46. A list of orchidaceous plants indigenous to Formosa.** (Japanese). Genkei MASAMUNE. (Trop. Hortic. **3**, 1933, 22-52, 6 pp. index).

74 genera and one or more species belonging to each are listed, 262 species and 6 varieties in all.

**47. Über die Resultate der Kreuzung zwischen den Gameten verschiedener Chromosomenzahl in *Petunia*.** (Vorl. Mit.) (Japanisch). Hideo MATSUDA. (Japan. Jour. Gen. **8**, 1933, 261-266).

Die Kreuzung Tetraploid ( $4 \times 14$ )  $\times$  Diploid ( $2 \times 14$ ) gab in  $F_1$  meistens die triploiden Nachkommen, was davon herrührt, dass 14 Chromosomen aus Tetraploid mit 7 aus Diploid vereinigt haben. Ausser den Triploiden sind die Heteroploiden mit 20, 22 und 23 Chromosomen beobachtet, was offenbar des Nichttrennens bei der Reduktionsteilung zu verdanken ist. Weiter sind je 1 Diploid und 1 Tetraploid entstanden. Bei der umgekehrten Kreuzung, nämlich, Diploid  $\times$  Tetraploid sind in einem Falle die Triploiden und in einem anderen die Diploiden entstanden.

Die Bestäubung von diploiden Pflanzen durch die Pollenkörner der polyploiden Pflanzen wurde ausgeführt, wobei die Nachkommen sich als diploid erwiesen haben,

**48. Über die Chromosomenzahl von *Cryptomeria* und *Taiwania*.** (Japanisch m. deutsch Zfg.). Kenzo MATSUMOTO. (Plants and Animals **1**, 1933, 1751-1756, 5 Textabb.).

Zwei naheverwandte Koniferenarten, *Cryptomeria japonica* und *Taiwania cryptomerioides*, wurden betreffend ihre Chromosomenzahl untersucht. Bei der ersteren Art  $n=11$  (P.M.Z.) und  $2n=22$  (Wurzelspitze), und bei der letzteren  $2n=22$  (Wurzelspitze).

**49. Immunological studies of mosaic diseases. III. Further studies on the distribution of antigenic substances of tobacco mosaic in different parts of host plants.** Takeshi MATSUMOTO and Kôetsu SOMAZAWA. (Jour. Soc. Trop. Agric. **5**, 1933, 37-48, 2 text-figs.).

The author has examined, whether the antigenic substance, and probably also the virus principle of the tobacco mosaic disease could pass through the xylem portion, either below or above the ringed part. Plants which were ringed were inoculated simply either below or above that part with the mosaic juice, and it was found that the portions, both above and below, show after a certain time the serological reaction as well as the symptom of disease. But in the experiment, where the plants were not only ringed, but also the central tissue lying within the xylem of the ringed part was



removed away, the infection was limited to that portion above or below the ringed part which was actually inoculated. Basing upon all these facts the author thinks that the movement of the antigenic substance in the xylem is prevented when it is not accompanied by living cells of the central tissue.

The author has further examined, whether the antigenic substance is present in the xylem under normal conditions, and got the positive evidence, even in cases when the xylem is liberated from other parts.

**50. Physiology and parasitism of the fungi generally referred to as *Hypochnus Sasakii* SHIRAI. II. Temperature and humidity relations.** Takashi MATSUMOTO, Wataro YAMAMOTO and Seiichi HIRANE. (Jour. Soc. Trop. Agric. **5**, 1933, 332-345, 5 figs.).

Formerly the authors have shown that the species generally referred to as *Hypochnus Sasakii* SHIRAI contains a number of strains which could be distinguished by the difference in their culture characters as well as in the mode of hyphal fusion (cf. Japan. Jour. Bot. **6**, (75), No. 267). In this paper the authors made a similar study concerning the temperature relation. In all strains of *H. Sasakii* taken for the present study the optimum temperature lies at  $\pm 28^{\circ}\text{C}$ , the maximum and the minimum being  $37^{\circ}$  and  $13^{\circ}$  respectively. *Rhizoctonia Solani*, the causal fungus of potato black scurf is clearly distinguished from any strain of *H. Sasakii* in its temperature relation, but the Indian strain from cotton seedlings as well as the causal fungus of the "banded sclerotial disease" of sugar-cane in India approaches it in some respects. A heavy infection of *Eichhornia crassipes* by *H. Sasakii* No. 1 takes place at  $29^{\circ}$ . Humidity is most effective in inducing the infection, the heaviest infection taking place at 100% relative humidity and the minimum being 85-88%.

**51. Physiology and parasitism of the fungus generally referred to as *Hypochnus Sasakii* SHIRAI. III. Histological studies in the infection by the fungus.** Takashi MATSUMOTO and Seiichi HIRANE. (Jour. Soc. Trop. Agric. **5**, 1933, 367-373).

The inoculation experiments of *Hypochnus Sasakii* on *Cinnamomum camphora*, *Eichhornia crassipes* and *Nicotiana Tabacum* have shown firstly that the penetration of hyphae takes place through the stomata, except in very young leaves where the cuticle is very thin. The microchemical tests have proven that the hyphae penetrate the cell-wall by dissolving the cellulose. Further, it was found that starch accumulates abundantly in the necrotic tissue which is due to the disturbance of starch hydrolyzation.

The discolouration of the tissue caused by the penetration of hyphae is not confined to the cells actually invaded by them, but also extends to those adjoining the intercellular hyphae or even in the cells lying near them, so that it is probable that a certain diffusible substance is produced by the fungal metabolism, which invades the cells, leading to the tissue dissolution.

**52. On the sea-grasses of Japan. (I). *Zostera* and *Phyllospadix*, with special reference to morphological and ecological characters.** Shigeru MIKI. (Bot. Mag. Tôkyô **47**, 1933, 843-862, 8 figs.).



10 species and 2 varieties of *Zostera* and *Phyllospadix* were hitherto reported by various botanists, as occurring in Japan, but the following 4 are really endemic, viz. *Zostera asiatica*, *Z. caespitosa*, *Phyllospadix japonicus* and *P. iwatensis*.

According to the author's morphological observations we distinguish monopodial and sympodial rhizomes. The flowering shoot is formed, firstly as the terminal of the rhizome with the terminal spadix, secondly as the terminal but with the vegetative shoot at its apex, and thirdly on its lateral branch or branches.

The seedling of *Zostera nana* has a primary root, and its terminal shoot creeps on the soil, that of *Z. marina* which is provided with a flowering shoot in its terminal in the same year passes the winter by means of the lateral shoot. The rhizome of *Z. marina* branched only in winter, and the growth of each node wants nearly half a month.

As to the ecological characteristics the *Zostera* species live on muddy or sandy places of the bay, while *Phyllospadix* grows upon the rocks washed by open sea-water.

Concerning the two genera here mentioned some species are limited to the temperate sea, others to cold current sea, while still others are widely distributed.

**53. Laminariaceae of the Kurile Islands.** (With Japanese résumé). Kingo MIYABE and Masaji NAGAI. (Trans. Sapporo Nat. Hist. Soc. **13**, 1933, 85-102).

11 species of *Laminaria*, of which *L. sachalinensis* and *subsimplax* are new, 3 of *Cymathæra*, 1 of *Kjellmanella*, *Costaria*, *Hedophyllum*, 2 of *Arthrothamnus*, 1 of *Thalassiophyllum*, 5 of *Alaria*, 1 of *Pleuropterum* are enumerated. The paper ends with a key for the identification of the species and forms contained in this paper.

**54. Über die Assoziation einer violettblühenden Iris.** Man'bu MIYOSHI. (Proc. Imp. Acad. **9**, 1933, 410-411, 1 Textabb.).

In einer gewissen Gegend von Hakone hat der Verf. eine neue Form von *Iris ensata* THUNB. var. *violacea* MIYOS. aufgefunden, welche forma *hexamera* genannt wurde. Sie ist durch den hexameren Bau der Perianthblätter ausgezeichnet. Dieser Befund ist umsomehr interessant, als es dabei sich um eine wildwachsende Pflanze handelt; es sei bemerkt, dass der hexamere Bau bei den kultivierten *Iris*arten sehr gemein ist.

**55. On the cytoplasmic framework of the plasmodium, *Physarum polyccephalum*.** A. R. MOORE. (Sc. Rpts. Tôhoku Imp. Univ. 4th Ser. **8**, 1933, 189-192).

As to the physical structure of cytoplasm there exist two different views. The one regards it as an emulsion without any special structural element, while the other considers it as possessing a fine permanent structure. In order to ascertain which view may be right the author has performed several experiments on the plasmodium of *Physarum polyccephalum*. One of them was to place a piece of the plasmodium into a wet filter pocket and set the whole in oat agar. It was observed that the plasmodium can pass through a dialyzing thimble of parchment paper into the oat agar without losing its life, the diameter of the pores of the thimble being  $5 \times 10^{-5}$  mm and even smaller. The next experiment was to squeeze it out through fine silk cloth

whose pores were in average  $5 \times 10^{-2}$  mm which led to the death of the plasmodium. It was further observed that it may live when the sieve cloth pore was over 0.25 mm in diameter and still further that if the plasmodium is cut by means of a capillary tube with the diameter 1/10 mm it can survive, but if it will be cut into shorter pieces it will die. Therefore there is a limit of its diameter as well as its length for the existence, and the author thinks that a certain "cytosquelette" or cytoplasmic framework must be present.

**56. A preliminary note on the karyological types of *Scilla japonica* BAK.** Toshitaro MORINAGA. (Japan. Jour. Gen. **7**, 1932, 201-205, 7 figs.).

In *Scilla japonica* growing near Hukuoka the author could distinguish three types karyologically different, viz. those with 26, 34-36, and 42-44 somatic chromosomes. In each of them the meiosis in the microsporocytes is irregular, which may explain the low fertility and the heteromorphism of this species in this locality. The above mentioned fact is in striking contrast to what SHIMOTOMAI had told the author about his observation on the same species growing near Sendai, which contains 16 gametic chromosomes and where the meiosis of the microsporocytes is quite regular.

**57. Karyological studies on a spontaneous haploid mutant of *Brassica Napella*.** Toshitaro MORINAGA and Eiichi FUKUSHIMA. (Cytologia **4**, 1933, 457-460, 10 figs.).

In the field where *Brassica Napella* is cultivated the authors have found a mutant plant, the examination of which has proven it to be haploid: its root-tip cell contains 19 chromosomes corresponding to the gametic number of typical *B. Napella*. It is markedly smaller than the diploid. In the heterotype division of pollen mother-cells in this mutant a certain number of bivalents are formed or not at all, and some laggards are often seen. Pollen grains are generally small and shrivelled, but some are large and perfect.

**58. On a new species of *Sphacelaria*.** (With Japanese résumé). Masaji NAGAI. (Trans. Sapporo Nat. Hist. Soc. **12**, 1932, 142-147, 1 fig.-group).

A new species *Sphacelaria Iridaeophytica* found on a frond of *Iridaea laminarioides* in Rumoi Harbour on the coast of Japan Sea in Hokkaidô is described with the help of figures. A table is given, comparing the essential characters of this species and 4 other related ones to each other.

**59. Meeresalgen aus Kamtschatka.** (M. jap. Zfg.). Masaji NAGAI. (Trans. Sapporo Nat. Hist. Soc. **13**, 1933, 12-19).

4 Chlorophyceen, 8 Phaeophyceen, und 4 Rhodophyceen sind enumeriert, die 1930 bei Petropawlowsk (Ostküste) und Osernaja (Westküste) angesammelt sind.

**60. On a new species of *Cymathaere* from the Kurile Islands.** Masaji NAGAI. (Proc. Imp. Acad. **9**, 1933, 531-534, 6 text-figs.).

The discovery of a new species *Cymathaere fibrosa* in several places of the Kurile Islands is announced. Its diagnosis is given.

**61. List of fungi collected in the Island of Kunashiri, Kurile.** (Japanese). Masaji NAGAI and Mitsutaro SHIMAMURA. (Trans. Sapporo Soc. Agric. & For. **25**, 1933, 71-89, 3 text-figs.).

Altogether 78 species are enumerated.

**62. Bambusaceae in Japan proper.** (Japanese). Takenoshin NAKAI. (Jour. Japan. Bot. **9**, 1933, 3-34, 8 figs.; 77-95, 5 figs.; 150-168, 7 figs.; 215-240, 13 figs.).

The Bambusaceae are considered by the author as a family which is independent from the Gramineae. The genera of this family found in Japan except Ryûkyû, Formosa, Bonin Isl., Saghalien, Korea, etc. are *Leleba*, *Bambusa*, *Dendrocalamus*, *Schizostachyum*, *Phyllostachys*, *Shibataea*, *Tetragonocalamus*, *Semiarundinaria*, *Pleistoblastus*, *Pseudosasa*, *Sasaella*, *Sasamorpha*, *Indocalamus*, *Sinobambusa*, and *Chimnobambusa*. The artificial key for the determination of these genera is given. For each genus are enumerated the names of the species included therein, often with diagnoses and figures. The following are new and described: *Shibataea chinensis* sp. nov., *Tetragonocalamus* gen. nov., *Pleistoblastus multifolius* sp. nov., *P. igaensis* sp. nov.

**63. Flora sylvatica koreana. Pars XX.** (Japanese with Latin diagnoses). Takenoshin NAKAI. (Pub. Forest Exp. Sta., Gov.-Gen. Chosen, 1933, 127 pp. and 25 pls. besides text-figs.).

This part contains the Bambusaceae, Myricaceae, Juglandaceae and Magnoliaceae found wild or cultivated in Korea.

The Bambusaceae comprise the genera *Pseudosasa* (2 sp.), *Sasamorpha* (3 sp.), *Pleistoblastus* (1 sp.), *Sasa* (3 sp.), *Phyllostachys* (3 sp.). The Myricaceae comprise the genus *Myrica* (1 sp.). The Juglandaceae comprise the genera *Platycarya* (2 sp.), *Juglans* (1 sp.). The Magnoliaceae comprise the genera *Schizandra* (2 sp.), *Kadsura* (1 sp.), *Illicium* (1 sp.) and *Magnolia* (3 sp.).

The paper contains 25 beautiful plates illustrating the habits of plants described.

**64. Chromosome number in some Angiosperms.** Goichi NAKAJIMA. (Japan. Jour. Gen. **9**, 1933, 1-5, 27 text-figs.).

The chromosome number, either  $n$  or  $2n$ , of 25 species belonging to the Dicotyledons and Monocotyledons is given.

**65. Einige Experimente über die Quellung und Keimung der Samen von *Astragalus sinensis*.** (Japanisch). Yôzô NAKAJIMA. (Proc. Soc. Crop Sc. Japan **5**, 1933, 443-459, 1 Figurengruppe).

Fortsetzung der Verf. Experimente über die Hartschaligkeit der Samen von *Astragalus sinensis* (vgl. Japan. Jour. Bot. **6**, (12), No. 29).

Der Verf. hat verschiedene Experimente ausgeführt, um die Quellung und Keimung der harten Samen zu beschleunigen, unter denen die folgenden zitiert werden. Der Wechsel der Temperatur, z.B.  $17^{\circ}$  während 18 Stunden und  $30^{\circ}$  während der nächsten 6 Stunden, das Eintauchen in die flüssige Luft (24 St.), in siedendes (5 Min.)

oder 50° Wasser (10 Tage), die Korrosion durch  $H_2SO_4$ ,  $HNO_3$  oder  $HCl$  tragen beträchtlich zur Quellung der Samen bei.

Bei jedem Samen von *Astragalus sinensis* kann man an einem Ende desselben den Teil erkennen, woraus das Wasser einzudringen beginnt.

**66. On the occurrence of the tetraploid plant of rice, *Oryza sativa* L.** Eiti NAKAMORI. (Proc. Imp. Acad. 9, 1933, 340-341, 3 text-figs.).

Among the  $F_1$  progeny from varietal cross of rice plants a new abnormal plant appeared. The cytological examination of its root-tip cells has revealed the presence of 48 chromosomes, which indicates the tetraploid nature of the plant. Spikelets are large, and awns are strongly developed, but the number of spikelets is reduced to 60% of the normal. The plant is poorly fertile, 27%.

**67. Haploide Reispflanzen.** (Japanisch). Seisuke NAKAMURA. (Japan. Jour. Gen. 8, 1933, 223-227, 2 Textabb.).

Der Verf. hat zwei haploide Reispflanzen bekommen, und zwar nicht als das Resultat der Bastardierungsversuche. Das Grössenverhältnis verschiedener Zellen der diploiden und haploiden Pflanzen beträgt ungefähr 1,5-3:1. Bei der Kernteilung bilden 12 univalente Chromosomen keine Gemini aus, was darauf beruht, dass dabei keine homogene Chromosomen vorhanden sind. Die Chromosomenverteilung nach beiden Polen bei der Reduktionsteilung der Pollenmutterzellen ist unregelmässig, sodass die dadurch produzierten Pollenkörner vorwiegend ganz leer sind. Die aus den obigen haploiden Pflanzen angekommenen haploiden Nachkommen blühen nicht im allgemeinen aus, und wenn sie selten dazu kommen, erfolgt kein Aufspringen der Antheren. Die künstliche Bestäubung durch den Pollen einer diploiden Pflanze hat bloss die diploiden Nachkommen angegeben.

**68. Der Wechsel der Chromosomenzahl bei der Nachkommenschaft der *Avena*-Artbastarde.** (Japanisch). Ichizō NISHIYAMA. (Japan. Jour. Gen. 8, 1933, 275-276).

Wenn man den Wechsel der Chromosomenzahl in den Nachkommen der polyploiden *Avena*-Bastarde, welche aus den Eltern verschiedener Chromosomenzahlen angekommen sind, näher untersucht, so kann man zwei Arten unterscheiden, nämlich den Weizen- bzw. Hafertyp. Zum ersteren gehören z.B. die triploiden Bastarde Hafers, *Avena barbata* ( $n=14$ ) $\times$ *strigosa* ( $n=7$ ) und *A. barbata* ( $n=14$ ) $\times$ *Wiestii* ( $n=7$ ).

Bei der heterotypischen Kernteilung der Pollenmutterzellen beobachtet man  $7_{II}+7_I$ , von denen die bivalenten Chromosomen sich ganz normalweise verhalten, und die Zahl von univalenten zwischen 7-14 schwankt, woraus in  $F_2$  die Chromosomenzahl nach den Individuen 14-28 ( $2n$ ) beträgt. Bei der Verminderungsgruppe ( $2n=20-14$ ) nimmt die Chromosomenzahl in jeder Generation bis zu  $2n=14$  ab, während bei der Vermehrungsgruppe ( $2n=22-28$ ) dagegen sie in jeder Generation bis zu  $2n=28$  zunimmt. Dies Verhalten stimmt ganz mit dem, was KIHARA früher bei den pentaploiden Weizenbastarden wahrgenommen hatte, überein.



Beim Hafertyp, z.B. bei *Avena barbata* ( $n=14$ )  $\times$  *fatua* ( $n=21$ ) können in der heterotypischen Kernteilung der Pollenmutterzellen der  $F_1$  Pflanzen, welche hochunfruchtbar sind, nur 2-11 Gemini aufgefunden werden, was auf die schwache Affinität der Chromosomen hindeutet. Bei den Nachkommen schwankt die Chromosomenzahl zwischen  $2n=42-67$  und keine Regelmässigkeit wurde nachgewiesen bezüglich dem Wechsel der Chromosomenzahl oder -zusammensetzung.

**69. The genetics and cytology of certain cereals. V. On the occurrence of an unexpected diploid in the progeny of pentaploid *Avena*-hybrids.** Ichizō NISHIYAMA. (Cytologia 5, 1933, 146-148, 1 fig.-group).

The  $F_1$  hybrids from *Avena fatua* ( $6x=42$ )  $\times$  *A. barbata* ( $4x=28$ ) are seen to behave irregularly in various respects, and are highly sterile. From their few kernels which were able to germinate the author got in  $F_2$  one plant with the chromosome construction  $17_{II}+8_I$ . This plant gave by self-fertilization 4 kernels, from which only one completely fertile individual was obtained. The latter looks like a diploid species and the karyological examination proved it to possess 7 bivalents closely paired in PMC,  $7_{II}$ . The fact has been confirmed, inasmuch as its crosses with a diploid species *A. strigosa* and *A. Wiestii* have shown also 7 normal bivalents.

**70. Genetical studies on *Sesamum indicum* L.** Sigeroku NOHARA. (Jour. Coll. Agric., Tokyo Imp. Univ. 12, 1933, 227-386, 10 pls. and 15 text-figs.).

Basing on the crossing of three types of *Sesamum indicum* the inheritance of the following characters was studied, of which the first one of each pair is dominant: Unbranched or branching, compound or simple leaves, long haired or short-haired body, presence and absence of nectar glands in leaf-axils, opening and closed fashion of corolla; all above monogenic difference. Some characters which rest upon digenic difference and some probable cases of linkage were also observed.

**71. On the structure of a fossil fern stem of *Cibotium*-type from the upper cretaceous of Iwate.** (With Japanese résumé). Yudzuru OGURA. (Bot. Mag. Tokyo 47, 1933, 748-753, 813, 1 pl. and 2 text-figs).

A fossil stem of a small tree fern from Iwate was placed at the author's disposal for its identification. The mode of departure of leaf traces, that of branching of foliar bundles, coupled with the structure of the fibro-vascular bundles, the absence of thick-walled sclerenchyma, the mode of branching of root traces have led the author to rank this fossil among *Cibotium*. It is however clearly distinguishable from any living species of *Cibotium* by the prominently wavy stelar ring. It is a new species, *Cibotium iwatense*.

**72. Symbolae ad floram Asiae orientalis 9.** (With Japanese résumé). Jisaburo OHWI. (Acta Phytotax. et Geobot. 2, 1933, 149-170, 1 fig.).

The following new species are described among others: *Euphrasia Duriëtziana*, *E. tarokoana*, *Cynoglossum alpestre*, *Hydrocotyle ranunculifolia*, *Circaea minutula*, *Chrysosplenium holochlorum*, *Calothodes polycarpa*, *Clematis tsugetorum*, *Ranun-*



*culus formosa-montanus*, *R. junipericola*, *R. nankotaisanus*, *Thalictrum myriophyllum*, *T. rubescens*, *Cynocrambe formosana*, *Carex phacopoda*, *C. purpureotingta*, *Agrostis arisan-montana*, *Avena abietorum*, *Calamagrostis landea*, *Festuca takasagoensis*, *Glyceria formosensis*, *Poa nankoensis*.

**73. Florula shikotanensis III.** Jisaburo OHWI. (Acta Phytotax. et Geobot. 2, 1933, 263-287).

Continuation of the author's former papers (cf. Japan. Jour. Bot. 6, (48), (81)). This third paper contains the Monocotyledones, Nos. 322-480, Gymnospermae Nos. 481-487, Pteridophyta Nos. 490-525, addenda Nos. 526-527.

**74. Bacterial diseases of plants occurring in Formosa III.** Norio OBABE. (Jour. Soc. Trop. Agric. 5, 1933, 157-166, 4 figs.).

Bacterial spot disease of jute plant. Its morphological, cultural and physiological characters are announced. The causal organism is *Bacterium Nakatae* TAKIMOTO, type B.

Bacterial leaf spot disease of soy bean plant, due to *Bacterium sojae* var. *japonica* TAKIMOTO.

Bacterial blight of mulberry, due to *Bacterium mori* BOYER et LAMBERT emend. E. F. SMITH.

**75. A haploid plant in *Portulaca grandiflora* HOOK.** (Japanese with English résumé). Elji OKURA. (Japan. Jour. Gen. 8, 1933, 251-259, 17 figs.).

As the results of certain crossing experiments the author got in  $F_2$  two haploid plants of *Portulaca grandiflora* ( $n=9$ ). Their stature is about half of the normal plant. In the first maturation division of P.M.C. 9 univalents are distributed towards two poles in various ways, lagging chromosomes being also present. In the homo-type division the half of dyad chromosomes are distributed so as to form four nuclei lacking the whole set of chromosomes, and consequently the non-functional empty pollen grains are formed. Haploid plants are wholly sterile. Normal  $\times$  haploid gave few seeds; one of them gave rise to a diploid progeny, which indicates the non-occurrence of the reduction in maturation division of the haploid plant.

**76. Beiträge zur Protoplasmaforschungen an *Spirogyra*-Zellen.** Tetsu SAKAMURA. (Jour. Fac. Sc., Hokkaido Imp. Univ., Ser. V, 2, 1933, 287-316).

Verschiedene körnige Zellteilchen in den *Spirogyra*-Zellen wurden im Hell- und Dunkelfeld beobachtet und nach ihren optischen Eigenschaften gruppiert.

I. Gleichmässig lichtbrechend im Dunkelfeld.

(a) Sehr lichtbrechend, roten Blutkörperchen der Säugetiere ähnlich bikonkav gestaltet.

(b) Kugelförmig, kleiner und schwächer lichtbrechend als a.

II. Optisch fast leer, aber von zarter Lichtlinie umgeben. Meistens kugelförmig.

(a) Gestalt leicht veränderlich.

(b) Kleiner als a, Gestalt ziemlich beständig.

Wenigstens zwei Teile wurden im Cytoplasma von *Spirogyra* unterschieden. Der eine ist der „Chloroplastenteil“, wo der Chloroplast und das Cytoplasma innig aneinander haften; der andere ist der „Nacktteil“, wo das Cytoplasma von Chloroplasten ganz frei ist.

Besondere Aufmerksamkeit wurde auf die Verhältnisse gerichtet, unter denen der Chloroplast vom Cytoplasma im Chloroplastenteil erfasst ist. Der Chloroplast ist in normalen Zellen tief eingebuchtet und ragt kielartig in den Zellsafrum hinein. Dadurch entsteht die „Chloroplastenrinne“. Die Rinne ist mit Cytoplasma gefüllt, das einer besonders eingehenden Beobachtung unterzogen wurde.

Die notwendigen Vorsichtsmaßnahmen bei der Herstellung der mikroskopischen Präparate bei der Lebendbeobachtung an *Spirogyra* sind eingehend geschildert. Die mechanische Schädigung durch den Druck des Deckglases und beim Uebertragen des Objektes aus einer Lösung auf den Objekträger, die besonders bei der Untersuchung an plasmolysierten d.h. des Turgors verlustig gegangenen *Spirogyra*-Zellen, hervorgerufen wird, wurde hingewiesen.

An plasmolysierten Zellen wurden Dunkelfeldbeobachtungen ausgeführt. HECHTSCHE Fäden, Cytoplasmareste auf der inneren Oberfläche der Zellmembran, Aufblähung der Plasmaoberfläche, Aggregation der Teilchen im Hohlraum zwischen Membran und Cytoplasma wurden besonders in Betracht gezogen.

Verschiedene Schädigung, d.h. Chloroplastentrennung, Plasmaquellung, Plasma-koagulation usw. in den nicht plasmolysierten Zellen sind besprochen. Unter Verwendung dieser Schädigungsmerkmale ist die Wirkung von Salzen auf *Spirogyra*-Zellen diskutiert. Alkalisalze zeigen im allgemeinen die Tendenz, auf das Cytoplasma, besonders auf dessen Oberfläche, verflüssigend und giftig zu wirken. Im Gegensatz dazu übt  $\text{CaCl}_2$  eine verfestigende und keine giftige Wirkung auf das Cytoplasma aus. Die antagonistische Wirkung dieses Salzes gegen Kaliumsalze, die von LEPE-SCHKIN nicht bemerkt worden war, wurde bewiesen.

Weiter sind die Zustände des Cytoplasmas in Zellen geschildert, die durch verschiedene hypertonische Salzlösungen plasmolysiert wurden. Vor allem ist zu erwähnen, dass bei der Plasmolyse in KCl-Lösung der Chloroplast seitwärts gleitet und eine oder zwei Massen bildet. Diese Chloroplastenklumpen sind oft vom Cytoplasmainschluss ausgeschlossen. Bei hoher Einstellung an der Plasmapartie, die nach der Gleitbewegung des Chloroplasten von diesem frei geworden ist, wird die Bildung von zahlreichen Bläschen festgestellt. Die Annahme wäre nicht unmöglich, dass diese Bläschen durch die Entmischung des Cytoplasmas oder Chloroplasten oder durch die Quellung der Chondriosomen entstehen.

Auch in hypertonischer Lösung KCl und  $\text{CaCl}_2$  haben die Neigung, verflüssigend bzw. verfestigend auf die plasmolysierte Plasmaoberfläche zu wirken, während NaCl in seiner Wirkungsweise etwa die Mitte zwischen beiden einnimmt, wobei es oft das Protoplasma teilweise verfestigt. Selbst KCl wirkt verfestigend auf das Protoplasma in höherer Konzentration (0.5 mm). Verf.

**77. Über die Bedeutung der H-Ionenkonzentration und die wichtige Rolle einiger Schwermetallsalze bei der Kugelzellbildung der Aspergillen.** Tetsu SAKAMURA und Fuji YOSHIMURA. (Jour. Fac. Sc. Hokkaido Imp. Univ., Ser. V, 2, 1933, 317-331).

In einer vorherigen Mitteilung hat SAKAMURA die exakte pH-Grenze für die Kugelzellbildung bei *Aspergillus oryzae* gefunden und diese hauptsächlich auf die Wirkung der H-Ionen selbst zurückgeführt. In den vorliegenden Untersuchungen wurde aber festgestellt, dass die Bedeutung der H-Ionen bei der Kugelzellbildung von *Asp. oryzae* und *Asp. niger* eher als eine indirekte aufzufassen und die direkte Wirkung auf die als Verunreinigungen in sehr kleinen Mengen vorhandenen Substanzen zurückzuführen ist. Diese sind nicht nur in den gewöhnlichen Chemikalien „zur Analyse“, sondern auch bisweilen in Präparaten von KAHLBAUM „mit Garantieschein“ gefunden worden. Durch die Adsorption mit Kohlenpulver konnten diese Verunreinigungen beseitigt werden, und die Kugelzellen wurden selbst in höherer Acidität nicht mehr gebildet. Auf Grund der angeführten Versuche und Literaturangaben liegt es nahe, diese Verunreinigung als Schwermetallverbindungen, so z. B. Cu-, Zn-, Ni-, u. a. Salze aufzufassen. Ausser diesen darauf fördernden Schwermetallverbindungen kann man auch die andere Gruppe Verunreinigung vermuten, die auf die Kugelzellbildung hemmend wirksam ist. Als solche werden Fe-, Mn-, Co-Verbindungen genannt. Das Resultat der antagonistischen Wirkung beider findet ihren Ausdruck in dem gefundenen Mass der Kugelzellbildung.

Verf.

**78. Beobachtungen über japanische Moosflora. (V).** K. SAKURAI. (Bot. Mag. Tôkyô **47**, 1933, 733-747).

Zunächst wird ein Schlüssel für die Bestimmung von japanischen *Fissidens*-arten angegeben, dann folgt die Beschreibung von 11 neuen Arten dieser Gattung. Der Aufsatz endigt mit der Aufzählung von 4 *Haplocladium*-arten und deren Varietäten.

**79. On the Japanese species of *Colus*. (Japanese).** Kaneyoshi SAWADA. (Trans. Tottori Soc. Agric. Sc. **4**, 1933, 166-173, 2 figs.).

Two Japanese species of the fungus genus *Colus* belonging to the Clathraceae, viz. *C. Schellenbergiae* SUMST. and *C. pentagonus* (BAILEY) SAWADA are described in detail with figures; synonyms are given.

**80. Descriptive catalogue of the Formosan fungi. Part VI. (Japanese).** Kaneyoshi SAWADA. (Rpts. Res. Inst. Formosa, Agric. Dpt. **61**, 1933, 99 pp., 2 pls., text-figs., index 13 pp.).

A continuation of the author's studies on Formosan fungi, formerly entitled "Reports on Formosan fungi" (cf. for instance Japan. Jour. Bot. **5**, (108), No. 356).

This part contains the names and descriptions of fungi found by the author and others in Formosa since the publication of Part V in 1931. The fungi enumerated belong to the Archimycetes (2 sp.), Phycomycetes (8), Ascomycetes (11), Basidiomycetes (34), and Fungi Imperfecti (22). Besides many species newly named by the author and already published the following new species are first presented, viz. *Oidium Agrimoniae*, *E. Emiliae-sonchifoliae*, *O. Heliotropii-indici*, *O. Cephalanthii*, and *O. Rosae-indicae*.

**81. Studien über die Bildung organischer Säuren in grünen Pflanzen II. Das Verhältnis zwischen dem Stickstoff- und dem Sauerstoffwechsel im ganzen**

**Körper von *Begonia Evansiana* ANDR.** Mannen SHIBATA. (Sc. Rpts., Tôhoku Imp. Univ. 4th Ser. 8, 1933, 189-192).

Zuerst sind die vom Verf. angewandten Methoden für die Bestimmung des Stickstoffes sowie der Oxalsäure ausführlich beschrieben, wobei als das die Verbrennung beschleunigende Reagenz die Überchlorsäure sich besser erwiesen hat als das Perhydrol.

Die Versuchsergebnisse sind wie folgt. In jeder Blattspreite von *Begonia Evansiana* nimmt die Säure in der Nacht zu, und zwar reichlicher in derselben des oberen jungen Blattes als des unteren alten. Die Ansäuerung nimmt in allen Organen mit ihrem Alter zu.

Bei den Knollen und Bulbillen überwiegt der lösliche Stickstoff immer dem Eiweiss-Stickstoff; beim Beginne der Knospenentfaltung aus den Knollen ist der lösliche Stickstoff durch den Amino-Stickstoff dargestellt, mit dem Zurücktreten der Amiden. Der Ammon-Stickstoff ist sehr gering vertreten.

In der Blattspreite ist der Amid-Stickstoff viel reichlicher vertreten, als der Ammon-Stickstoff, dabei findet sich die Nachtzunahme des Ammon- und Amid-Stickstoffes statt, während der Eiweiss-Stickstoff fast keine Schwankung erfährt. Bei den Blüten entspricht der Ansäuerung eine überwiegende Menge des Ammon- bzw. Amid-Stickstoffes. Im Blattstiel und Stengel überwiegt die Menge des Ammon-Stickstoffes der des Amid-Stickstoffes.

**82. Zur Karyogamie der Gattung *Chrysanthemum*.** Naomasa SHIMOTOMAI. (Jour. Sc. Hiroshima Univ. Ser. B, Div. 2, 2, 1-100, 10 Taf. und 52 Figurengruppe).

In dieser Abhandlung hat der Verf. hauptsächlich seine früher an verschiedenen Orten veröffentlichten Angaben bezüglich der Polyploidie der japanischen *Chrysanthemum*arten mit Erweiterung zusammengestellt, wofür vgl. z. B. Japan. Jour. Bot. 5, (109), Nr. 358, 6, (51), Nr. 179, (85), Nr. 304-305 usw. Der Ansicht Verfs. nach muss die Entstehung der Polyploidie der *Chrysanthemum*arten nicht nur der natürlichen Bastardierung zwischen verschiedenen Arten, sondern auch teilweise dem Einfluss äusserer Faktoren zu verdanken sein: die Arten mit der Grundzahl oder niedriger Chromosomenzahl wachsen auf den Feldern oder Bergen, während diejeniger höherer Polyploidie nur auf dem Meeresküste aufgefunden wurden.

**83. Germination experiments of pollen in *Brassica* and the application of their results to the identification of its species.** (Japanese.) Makoto SISA. (Japan. Jour. Gen. 8, 204-206).

The artificial germination of pollen in *Brassica* was thought to be very difficult, but the author's studies have shown that their germination can be accelerated by the culture under low hydrogen-ion concentration (pH higher than 7 or even 8.4) or under comparatively highly concentrated sugar solution, and by using agar or gelatine according to different species.

In the tabular form are shown the germination rates of pollen in a number of *Brassica* species in gelatine or agar as well as the optimum pH for the same process. In *B. campestris*, *Rapa*, *pekinensis*, *chinensis* and *nipponica* the haploid chromosome



number is 10, and notwithstanding this equality they differ not only in their external form, but also in the optimum pH for pollen germination as well as their fondness of gelatine or agar as germination bed. This indicates that the systematic classification of these species as different ones notwithstanding the same chromosome number is rightly founded.

**84. Ueber die Keimfähigkeit des Pollens der japanischen Mispel (*Eriobotrya japonica* LINDL.).** (Japanisch). Makoto SISA. (Zeit. f. Gartenbau 4, 1933, 15-18, 3 Textabb.)

Der Stärkegehalt des Pollens von *Eriobotrya japonica* ist nach seinem Entwicklungszustande höchst verschieden: im Blütenknospenzustande ist er mit Stärkekörnern vollgepfropft, welche allmählich abnehmen bis zur Zeit des Blütenöffnens. Wenn die Keimfähigkeit des Pollens im letzteren Blütenstadium 42.7% beträgt, ist sie im Blütenknospenzustande null. Diese letztere Tatsache rührt davon her, dass im letzteren die Diastasewirkung noch nicht eingetreten ist, sodass wenn dem Pollen im demselben Stadium etwas Diastase hinzugefügt wird, man seine Keimung veranlassen kann. Der Pollen kann unter niederer Temperatur, z. B. zwischen 2-3°, nicht keimen. Dabei ist der folgende Versuch von Interesse. Einiger Zeit, nachdem er unter höherer Temperatur, z. B. 20°, einmal zu keimen begonnen hat, setzt man ihn unter der niederen und dann wird seine weitere Keimung gar nicht beeinträchtigt. Indem das Blütenöffnen von *Eriobotrya* im Winter geschieht, wird der Pollen in der Natur im Freien gewöhnlich nicht keimfähig sein, doch wenn bei einem gewissen besonders warmen Wintertage seine Keimung einmal zu erfolgen beginnt, wird er diesen Vorgang weiter fortsetzen können, obschon sobald die Kälte wieder eintreten wird.

**85. On the female tendencies of the embryo-sac-like giant pollen grains of *Hyacinthus orientalis*.** Isamu STOW. (Cytologia 5, 1933, 88-108, 2 pls. and 3 text-figs.)

The author has determined the relative reduction power and the hydrogen-ion concentration of the embryo-sac-like giant pollen grains in *Hyacinthus orientalis*, which he has formerly succeeded in producing by certain artificial method (cf. e. g. Japan. Jour. Bot. 5, (47), No. 154). The reduction power was chiefly determined by means of the colour tone taken by the watery solution of various dyes, e.g. methylene blue, neutral red, neutral violet, safranin, while the intracellular hydrogen-ion concentration was determined by means of the indicator method (e.g. by using the indicator solutions after CLARKE etc.) It was found firstly that the reduction power of the cytoplasm of the giant pollen grain is greater than that of the normal grain, either under germinated or non-germinated condition, and secondly that both agree to each other in hydrogen-ion concentration. It is to be noticed that a quite similar relation as above has been observed between the male and female sex-cells of some plants and animals, in which the female is provided with the stronger reduction power.

The giant and the normal pollen grains were put together under sterile condition and brought to germination. The intracellular reduction power of the cytoplasm of the giant pollen grains thus influenced by the normal ones was scarcely changed. In



further study the author has seen the case, where the reduction power was decreased after being thus influenced. Further the author has observed the interesting phenomenon: the pollen-tube of the normal grain entwined two and half times around the giant, and sticks to it tightly, as if the latter were the female apparatus. In another case he could see that a sperm-nucleus was just getting into the giant out of the tip of a pollen-tube.

The author's general conclusion founded on all such observations is that the embryo-sac-like pollen grain has the female tendencies, not only in its external appearance but also in its physico-chemical character as well as its physiological function.

**86. Spicilegium pteridographiae Asiae orientalis V.** (With Japanese résumé). Motozi TAGAWA. (Acta Phytotax. et Geobot. **2** 1933, 189-205).

The following new species are contained: *Plagiogyria Koidzumii*, *Dryopteris commixta*, *D. Koidzumiana*, *D. psilosora*, *Polystichum Obai*, *Diplazium bittyuense*, *D. sikosiroyamaense*, *D. nipponicum*, *D. Tasiroi*, *D. okinawaense*.

**87. Über die Chromosomenzahl bei einigen Amaranthusarten.** (Japanisch). Fumi TAKAGI. (Bot. Mag. Tôkyô **47**, 1933, 556-557, 1 Abb. gruppe).

Unter sechs von der Verfasserin untersuchten *Amaranthus*arten sind bei drei  $n = 17$  und  $2n = 34$ , und bei den übrigen  $n = 16$  und  $2n = 32$ .

**88. Über das quantitative Verhältnis zwischen dem spezifischen Gewicht und dem spezifischen Pulvergewicht und die Zuverlässigkeit der Pulvervolumenmessung mittels der Methode nach KÔKETSU.** (Japanisch m. deutsch. Zfg.). Toratarô TAMAI und Riichiro KÔKETSU. (Bot. Mag. Tôkyô **47**, 1933, 632-639, 1 Textabb.)

Um die hohe Genauigkeit der Pulvervolumenmessung, die für die Durchführung der KÔKETSUSchen Pulvermethode nötig ist, sind die folgenden Experimente gemacht, wobei das wahre und das sog. spezifische Pulvergewicht zueinander verglichen werden. Als das wahre spezifische Gewicht an den Pflanzenmaterialien nur schwer bestimmbar ist, haben die Verf. für die Untersuchungsmaterialien die Mineralien, wie Amber, Quartz, Glas usw. und auch Stärke benutzt, von denen es sehr leicht genau zu bestimmen ist. Die Verf. haben solche wahre spezifische Gewichte mit den sog. spezifischen Pulvergewichte (d.h. Gewichte des Pulvers solcher Materialien) verglichen und zwischen beiden das Verhältnis  $y = bx$  oder  $y = 0,657x$  gefunden, wobei  $x$  das erstere Gewicht und  $y$  das letztere zeigen. Die Zuverlässigkeit des von den Verf. benutzten Methode der Pulvergewichtsbestimmung wurde somit vollauf bestätigt.

**89. Opinion of Dr. KOZHIN on Citrus classification.** (Japanese with English résumé). Tyôzaburô TANAKA. (Studia Citrol. **5**, 1932, 251-263).

KOZHIN is not in accord with the classification system of *Citrus* as proposed by the author. This system comprises among others a number of horticultural forms

(cultigens), each of which is considered by the author as a Linnean species in the strict sense of systematic botany. The chiefest reason of the argument KOZHIN's against the system is that the horticultural forms cannot be equalized in their origin with Linnean species, especially because the agency of man has contributed largely to their existence. The author thinks on the contrary that the opinion that the garden culture favours the formation of new forms is quite erroneous and that there is no reason why natural laws act on cultivated and wild forms differently; besides the agency of man will have no effect whatever upon the production of chance seedlings, either by mutation or hybridization. Each horticultural as well as wild form in his system may be well considered in the same right as a Linnean species. His classification system will not at all be affected by the KOZHIN's argument.

The paper ends with the comparison of the SWINGLE's and his system, wherein the author insists on the superiority of the latter.

**90. Botanical discoveries on the *Citrus* flora of China.** Tyôzaburô TANAKA. (Mem. Tanaka Citrus Exp. Sta. **1**, 1932, 12-36).

The paper is concerned with the description of the results of studies by Western and Japanese authors, incl. those of the author himself. The introduction of various Chinese *Citrus* forms into Europe as well as Japan is described. As to the *Citrus* flora of China the author's general conclusion is: in the southernmost region of the Chinese coast citrons, lemons, sweet oranges, shaddocks, and large-fruited mandarins are predominating. Towards the north the lemons disappear, and large-fruited loose skin oranges as Ponkan and Tankan take the lead. Still towards the north the citrons disappear and small-fruited mandarins become important. In the northernmost region only hardy species like *Citrus junos* and small-fruited mandarins exist while others disappear.

For other details see the original.

**91. *Citrus Wilsonii*, species nova.** Tyôzaburô TANAKA. (Mem. Tanaka Citrus Exp. Sta. **1**, 1932, 37-38).

The diagnosis is given. It will have unquestionably *Citrus junos* as one of its parents, and seems to be a cultigen which has originated through the chance seedling.

**92. Philippine Rutaceae-Aurantioideae.** (Revision aurantiacearum VII). Tyôzaburô TANAKA. (Trans. Nat. Hist. Soc. Formosa **12**, 1932, 418-433).

After the publication of MERRILL's "An enumeration of Philippine flowering plants," Vol. 2 in 1932, where 31 species and 7 varieties of the Aurantioideae are listed, no important progress has been made in this direction. The present paper contains the author's revision of the list. Altogether 51 species are enumerated, of which 22 belong to the genus *Citrus*. A number of new varieties were created.

**93. General remarks on the genus *Fortunella*.** (Japanese with English résumé). Tyôzaburô TANAKA. (St. Citrologica, Tanaka Citrus Exp. Sta. **5**, 1932, 141-154, 6, 1933, 19-40).

The genus *Fortunella* was established by SWINGLE in 1915 to include four species of kumquats hitherto ranked among *Citrus*. One of most prominent features which distinguishes *Fortunella* from *Citrus* is that on the underside of leaves of the former the veins are obscure and oil glands are well developed, having permanent exudation of resinous substances. To four species mentioned by SWINGLE, viz. *F. japonica*, *F. margarita*, *F. crassifolia* and *F. Hindsii* the author has added *F. obovata* and *F. polyandra*. The original description of the species and that of raw fruits are given.

**94. Florula of the Island of Kaibatô (Todomoshiri) II.** Misao TATEWAKI and Ujimoto KIMOTO. (Acta Phytotax. et Geobot. **2**, 1933, 227-262), 2 figs.

Continuation of the authors' first report (cf. Japan. Jour. Bot. **6**, (89)). This second part contains the enumeration of plants belonging to the Dicotyledons, Salicaceae to Asteraceae, Nos. 23-351.

**95. Geschlechtsschrosomen bei einigen Lebermoosen III.** (Japanisch m. deutsch. Zfg.) Seizi TATUNO. (Bot. Mag. Tôkyô **47**, 1933, 715-720, 25 Textabb.)

Die Chromosomenformeln wurden bei zwei Lebermoosen festgestellt, wie folgt:

	Gametophyt	Sporophyt	Heteropyknose
<i>Riccardia pinguis</i>	9x, 9y	18+x+y	deutlich
„ <i>blasioides</i>	9x, 9y	18+x+y	deutlich, schwach erkennbar

**96. Effekt der Bastardierung von *Brassicoraphanus* durch *Brassica* und *Raphanus*.** (Japanisch). Yasufusa TERASAWA. (Japan. Jour. Gen. **8**, 1933, 229-230).

Der früher vom Verf. durch die Bastardierung *Brassica pekinensis* × *Raphanus sativus* bekommene amphidiploide Bastard *Brassicoraphanus* (vgl. Japan. Jour. Bot. **6**, (55) und (89)) wurde mit den folgenden Arten als Pollenpflanzen künstlich bastardiert, nämlich *Raphanus sativus*, *Brassica oleracea*, *chinensis*, *pekinensis*, *cernua* und *Napus*, woraus nur wenige F<sub>1</sub> Pflanzen entstanden sind, ausgenommen im allerletzten Falle, wobei eine ziemlich grosse Anzahl Nachkommen bekommen sind. Die Kreuzung zwischen den *Brassicoraphanus*individuen hat auch viele Nachkommen geliefert. Im Falle, wo *Brassicoraphanus* als Pollenpflanze dient, sind die Resultate nicht ganz klar wegen des oftmaligen Stattfindens der Pseudogamie bei den *Brassica*arten.

**97. Unterschied der Keim- und Endospermentwicklung bei den reziproken Artbastardierung des Weizens.** (Japanisch). Shunjiro WAKAKUWA. (Japan. Jour. Bot. **8**, 1933, 279-280).

Es wurde bei der Bastardierung zwischen den Weizenarten verschiedener Chromosomenzahl nachgewiesen, dass dieselbe vielchromosomig ♀ × wenigchromosomig ♂ gutkeimfähige Körner produziert, während die umgekehrte geschrumpfte schlechtkeimfähige liefert. Wenn man nun die Endospermentwicklung von *Triticum Spelta* (n = 21) und *T. polonicum* (n = 14) zueinander vergleicht, sieht man, dass sie viel schneller verläuft bei der ersteren wie bei der letzteren. Bei *T. Spelta* ♀ × *T. polonicum* ♂ geht dieser Vorgang noch schneller vor als bei *T. Spelta*, während bei dem

umgekehrten Bastard er viel verzögert wird, sogar im Vergleich zu *T. polonicum*. *T. Spelta* ♀ × *T. polonicum* ♂ ist genotypisch als (AABBDD) × (AABB) aufzufassen, weshalb das Endosperm = 3AB+2D wegen Doppelbefruchtung. *T. polonicum* ♀ × *T. Spelta* ♂ = (AABB) × (AABBDD), weshalb das Endosperm = 3AB+D, d.h. das D-Gen findet hier keinen Paarling, was zur Störung des Gleichgewichtes und somit zur schlechten Entwicklung des Endosperms führt.

**98. Biologie von *Mitrastemon Yamamotoi* MAKINO (Rafflesiacee). I. Früchte und Samen.** (Japanisch m. deutsch. Zfg.) Kiyohiko WATANABE. (Bot. Mag. Tôkyô 47, 1933, 798-805, 3 Fig. gruppe).

Die beerenartigen Früchte von *Mitrastemon Yamamotoi*, eine japanische Rafflesiacee, kommen sehr selten zur Reife und dann sind sie embryohaltig. Der Embryo besteht dabei bloss aus vier Zellen und wird vom einschichtigen Endosperm umgeben. Die Früchte tragen immer die Chlamydosporen einer Pilzart, welche selten in die Embryosäcke eindringt und ganz unschädlich ist.

**99. Ungeschlechtliche Fortpflanzung von *Mitrastemon Yamamotoi*.** Kiyohiko WATANABE. (Proc. Imp. Acad. 9, 1933, 412-415, 2 Textabb.).

Die Infektion der Wirtspflanze *Shiia Sieboldii* durch *Mitrastemon Yamamotoi* findet sehr selten statt. Die Parasitenfäden derselben laufen parallel zur Längsachse im Kambium des Wirtes oder nahe derselben und werden künftig wagerechte Fäden im Holz werden. Die primären wagerechten Fäden in der Rinde, welche mit denselben in Verbindung stehen, verwelken im zweiten Jahre und sind durch die sekundären ersetzt, und im dritten Jahre die letzteren durch die tertiären, um auf dem Netze der letzteren die Blüten sich entwickeln zu lassen. Nach der Fruchtreife sterben alle Fäden in der entsprechenden Region ab. Nach der Verfs. Ansicht beginnt die in Rede stehende parasite Pflanze 3-4 Jahre nach der Infektion aufzublühen, weiter können deren Vegetationsorgane über 15 Jahre lang ungeschlechtlich fortpflanzen, wobei jedes Jahr die Blüten entwickelt werden.

**100. On two genera of algae in the sea of Japan.** (Japanese). Yukio YAMADA. (Rpts. Sta. Algal Res. Hokkaidô Imp. Univ., No. 1, 1933, 7-10, 2 text-figs.).

*Ptilota Okadai* sp. nov. and *Cymopolia* sp. which may correspond to *C. van Bosseae* SOLMS, are contained in this paper.

**101. Observationes ad floram formosanam VI-IX.** (With Japanese résumé). Yoshimatsu YAMAMOTO. (Jour. Soc. Trop. Agric. 5, 1933, 54-56, 178-184 with 3 text-figs., 346-356 with 2 text-figs., 405-407).

The following new species are described among others: *Cheirostylis taiwanensis*, *Acalypha suirebiensis*, *Glochidion longipedicellatum*, *Acer taiwanense*, *Amorphophallus Niumurai*, *Eurya renegechiensis*, *E. Hayatai*, *E. Suzukii*, *Sakakia Hayatai* (MASAMUNE et YAMAMOTO), *S. longicarpa*, *Pseudoeurya crenatifolia* (*Pseudoeurya* nov. gen.), *Vicia shinchikuensis*, *Begonia bui-montana*, *Rhododendron ovatosepalum*.



**102. Karyotypes in *Rumex Acetosa* L. and their geographical distribution.** (Japanese with English résumé). Yukio YAMAMOTO. (Japan. Jour. Gen. **8**, 1933, 264-274, 4 text-figs.)

There are in all eight karyotypes of *Rumex Acetosa*, including three newly discovered ones by the author. Their geographical distribution in Japan is pointed out for the types I, II, and III with help of a map. Why such diverse karyotypes came to existence is explained by the author by means of a hypothesis, which may be resumed as follows: the chromosomes of new shape may be produced as the result of complicated chromosomal changes in the progeny of the triploid intersexes, so often found in *Rumex Acetosa*, and such changes may lead to the differentiation of karyotypes.

**103. Karyologische und embryologische Studien über einige Bambusarten.** (Vorl. Mitt.). (Japanisch m. deutsch. Zfg.). Atusi YAMAMURA. (Bot. Mag. Tôkyô **47**, 1933, 551-555, 3 Textabb.)

Bei 7 Bambusen, welche zu den Gattungen *Sasa*, *Sasamorpha*, *Pleioblastus* und *Bambusa* gehören, sind die Chromosomenzahlen  $n$  und  $2n$  festgestellt, wobei  $n = 24$ ,  $2n = 48$  und in einem Falle  $n = 72$  beobachtet wurden. Die Grundzahl ist hier 12; einige Arten sind tetraploid und eine ( $n = 72$ ) ist hexaploid. In dem Embryosack einiger Gattungen wurden der aus 300 Zellen bestehende Antipodenapparat nachgewiesen.

**104. On the behaviour of pollen tube in the production of seedless fruits caused by the interspecific pollination.** (Japanese with English résumé). Sadao YASUDA. (Japan. Jour. Gen. **8**, 1933, 239-244.)

The parthenocarpy is induced by interspecific pollination, e.g. egg plant ♀ × *Petunia violacea* ♂, squash ♀ × *Calystegia japonica* ♂, etc. The parthenocarpy will be successful, when the pollen tube is able to penetrate deeply into the style, but it fails when its growth into the latter is inhibited. The growth of pollen tube seems to be influenced by special substances in the style which were perhaps originally produced in the ovary.

**105. Ethyl alcohol as a fixative for smear materials.** Kono YASUI. (Cytologia **5**, 140-145, 1 text-fig.)

Ethyl alcohol fixation of smear materials was found to be quite suitable for the chromosomal study. The materials treated with this reagent are well stainable with various dyes. For smear materials ethyl alcohol gives equally good results as BENDA's, NAWASHIN's or CARNOY's solution or even better in certain cases.

**106. On three species of *Alternaria* parasitic on cruciferous plants.** (Japanese with English résumé). Hazime YOSHII (Bult. Sc. Fak. Terk. Kjušu Imp. Univ. **5**, 1933, 221-235, 5 text-figs.).

*Alternaria Brassicae* is parasitic on *Brassica oleracea* and its allied species, *A. hercuba* on *B. chinensis*, *Rapa*, *Napella*, *oleracea* as well as *Raphanus sativus*, while *A. Brassicae* var. *macrospora* attacks *Raphanus sativus*, *Brassica oleracea*, *chinensis* and related species.



**107. Pathological studies on watermelon wilt. I. On the mode of infection of the causal fungus, *Fusarium niveum* EFS.—II. On the migration of microconidia.** (Japanese with English résumé). Hazime YOSHII. (Bult. Sc. Fak. Terk. Kjušu Imp. Univ. **5**, 1933, 313-326, 12 figs.; 578-589, 5 figs.).

Ad I.—*Fusarium niveum* penetrates at first into the host's root (watermelon) either through the root-cap or directly into the primary meristem, and then into the stele. The hyphae run at first in the intercellular space, but after their penetration into the young tissue of the host they will enter the cell-cavities by the rupture of cell-walls. The wilting is caused by such action of the causal fungus.

Ad II.—When the stem of watermelon invaded by *Fusarium niveum* is examined its hyphae will be seen in the portion of the host's stem which is very remote from the soil surface; this was supposed generally to be due to the very rapid elongation of hyphae. The study of the tube culture of this fungus for a long time has however convinced the author of the fact that such rapid elongation as hitherto presumed is out of question. This has led the author to the probable conclusion that the phenomenon above announced may be explained by the infection by microconidia which may be transported rapidly from below upwards by the transpiration current in the vessels of the host.

**108. Studies on *Gloeosporium Kawakamii* MIYABE IV. On the anthracnose of *Paulownia tomentosa* caused by *Gloeosporium Kawakamii* MIYABE.** (Japanese with English résumé). Hazime YOSHII. (Bult. Sc. Fak. Terk., Kjušu Imp. Univ. **5**, 1933, 524-545, 11 figs.).

The leaf and stem anthracnose of *Paulownia tomentosa*, due to the attack of *Gloeosporium Kawakamii* MIYABE is prevalent in all regions of Japan, where the paulownia-trees are cultivated. The infection takes place at first through the adpresorium by means of haustoria arising from it which pass through the cuticular layer of the host, so that after 24 hours the hyphae enter the epidermal cells and already after 3 days the disorganization of the invaded tissue begins to take place. Though the infection will cause severe damage on young plants, in fully grown ones the penetration of the fungus may be prevented by the formation of cork layers.

*Paulownia coreana* UYEKI from Korea was found to be more resistant against the attack of this fungus than *P. tomentosa* of Japan proper.

**109. How does *Piricularia Oryzae* penetrate into the host?** (Japanese). Hazime YOSHII. (Jour. Plant Prot. **20**, 1933, 841-844, 1 fig.).

As to the mode of penetration of the hyphae of *Piricularia Oryzae*, the causal fungus of the blast disease of rice-plant, some think that it takes place exclusively through the cuticle, while others insist on the possibility of penetration both through the cuticle and the stomata. To decide between these two possibilities the following observations were performed. Some leaf-pieces of rice plant were placed in direct contact with the fungus culture in the PETRI dish, taking care for necessary moisture and temperature. After three days they were taken off, and after having been deprived of silica by means of hydrogen fluoride they were fixed and cut into microtome sections according to the usual procedure. The sections were doubly

stained. The observation of the preparations thus made has revealed the following facts. The adpressoria can be produced anywhere on the leaf surface, either near the stomata or remotely from them; from each adpressorium a fine haustorium protrudes, which is able to penetrate into the cuticular layer. It is remarkable that at that time the cuticle produces a callosity on its side turned towards the cell-cavity, and each haustorium ends with a small sac-like body placed just outside this callosity. Hyphae are produced from this sac-like body, which not only fill up soon the entire cell-cavity, but will penetrate into their neighbouring cells through the rupture of septal walls. The author could never find the penetration of the haustoria through the stomata, which in the Gramineae are generally closed up and will not allow the penetration of the hyphae therefrom.

**110. Studies in the cytology of Pteridophyta. III. The morphology of spermatozoids in eight species of ferns.—IV. On the spermatozoids of *Selaginella*, *Isoetes* and *Salvinia*.** Akira YUASA. (Bot. Mag. Tôkyô 47, 1933, 689-696, 26 text-figs. and 6 graphs; 697-709, 17 text-figs. and 2 graphs).

Ad III.—Through the observations of the dried spermatozoids, which are either stained or unstained after having been fixed by osmic flame, the author has studied the arrangement of cilia, the length and width of the border-brim, the length of the cilia-bearing band, the number of cilia, the length of the extended spermatozoid and the structure of its anterior part concerning the following eight species belonging to the Polypodiaceous genera), viz. *Athyrium* (2 species), *Blechnum* (1), *Davallia* (1), *Polystichum* (2), *Pteris* (1), and *Notogramme* (1). As the results are more or less variable according to the species examined, it is hardly possible to describe them here one by one, so that those who wish to know further should consult the original paper.

Ad IV.—The spermatozoid of *Selaginella involvens* consists chiefly of the nuclear part, and also of the cilia-bearing part with two long cilia, the posterior appendage being composed of three grains and the little process at its posterior end. Two cilia are attached to the top of the cilia-bearing part, and have a common basal swollen part. The spermatozoid rotates in left-handed direction.

The spermatozoid of *Isoetes japonica* consists of two coils, and comprises the nuclear part, the plasmic band, the border-brim, the cilia-bearing part and the cilia. The fin-like appendage is also present. The number of cilia is generally 11, of which 3 point forwards and the others rearwards.

The spermatozoid of *Salvinia natans* is composed of the nuclear part, the border-brim, and the plasmic band. The number of cilia is in average 19.2. It rotates in right-handed direction.

## Abstracts Nos. 111–240

(Referring chiefly to the principal papers in Botany and allied subjects  
which have appeared in Japan during January-June 1934)

**111. Chromosome numbers in the genus *Cirsium* I.** (With Japanese résumé).  
Toshiyuki AISHIMA. (Bot. Mag. Tôkyô **48**, 1934, 150–151, 164).

The chromosome number in 30 species of *Cirsium* is recorded. There are its three types, viz. 17, 34 ( $17 \times 2$ ) and 51 ( $17 \times 3$ ), so that 17 may be the basic number.

**112. Systematic anatomy of the leaves of some Japanese *Carex* V-VI.**  
(Japanese). Sigeo AKIYAMA. (Bot. Mag. Tôkyô **48**, 1934, 143–149, 4 fig.-groups;  
249–258, 6 fig.-groups).

The description refers to Sec. Careyanae, viz. *Carex siderosticta*, *C. pachygyna*  
and *ciliato-marginata*, and to Sec. Canescentes (under the subgenus Vigneae), viz. *C.*  
*lagopina*, *C. norvegica*, *C. canescens*, *C. traiziscana*, *C. nemurensis*, *C. brunnescens*  
var. *sphaerostachya*.

**113. Lichenologische Notizen III, IV, V.** (Japanisch, deutsch und lateinisch).  
Yasuhiko ASAHINA. (Jour. Japan. Bot. **10**, 1934, 8–16, 8 Fig.; 299–304, 8 Fig.; 352–  
357, 9 Fig.).

In den vorliegenden Notizen sind die folgenden japanischen Flechten enthalten,  
welche im allgemeinen in japanisch und deutsch beschrieben, aber oft mit lateinischen  
Diagnosen versehen sind: *Corscium viride*, *Baeomyces insignis*, *B.i.* var. *pachycarpa*,  
*Polychidium muscicola*, *Parmelia abstrusa*, *P. limbata*, *P. relicina*, *Bombiliospora*  
*domingensis*, *Anaptychia leucomelaena* var. *multifida*.

**114. Über das Vorkommen und die Bedeutung der Wurzelpilze in den  
Landpflanzen.** Tôichi ASAI. (Japan. Jour. Bot. **7**, 1934, 107–150, 13 Textabb.).

**115. Breeding of a new interspecific type between *Hibiscus esculenta* and *H.*  
*Manihot*.** (Japanese). Tomowo CHIZAKI. (Proc. Crop Sc. Soc. Japan **6**, 1934,  
164–172).

A hybrid was made by the author by the cross between *Hibiscus esculenta* ♀  
( $2n = 126-134$ ) and *H. Manihot* ♂ ( $2n = 60$ ). The offspring of this hybrid which are  
now in their  $F_3$  generation have shown  $2n = 98$  and  $2n = 192$ . The pollen formation is  
irregular, and the author could observe several times certain stages belonging to the  
non-reduction and the formation of restitution nuclei. Dyads are mostly prevalent,  
but sometimes tetrads, rarely monads, triads, pentads, and hexads are observed.  
Pollen is large or small. The  $F_2$  plant may be amphidiploid. Further studies are  
intended.

**116. Entwicklung der Sporangien von Myxomyceten.** (Japanisch m. deutsch. Zfg.). Yoshikadzu EMOTO. (Bot. Mag. Tôkyô **48**, 1934, 61-67, 15 Abb.; 152-158, 17 Abb.).

Diese zwei Aufsätze beziehen sich auf drei Stemonitaceen, *Comatricha longa*, *Camproderma arcyronema*, *Stemonitis fusca* und einige Heterodermaceen sowie Reticulariaceen, *Cribraria intricata*, *Dictyoaethalium* var. *cinnabarium* und *Enteridium Yabeaenum*.

**117. Über die in Japan nicht bekannten Myxomyceten.** (Japanisch m. deutsch. Zfg.). Yoshikadzu EMOTO. (Bot. Mag. Tôkyô **48**, 1934, 206-209, 5 Abb.).

*Cribraria ferruginea*. MEYLAN und *Physarum psittacinum* DITMAR.

**118. Die Myxomyceten Japans I, II, III.** (Japanisch m. deutsch. Zfg.). Yoshikadzu EMOTO. (Bot. Mag. Tôkyô **48**, 1934, 279-287, 3 Abb.; 342-353, 11 Abb.; 408-417, 6 Abb.).

In I. Mitteilung erörtert der Verf. die allgemeinen Charakteren (Entwicklung, Gestalt usw.) der Myxomyceten und enumeriert die bisher bekannten Gattungen der ganzen Welt, welche nach dem System LISTERS angeordnet sind. Nach dem Verf. wurden bisher in Japan 44 Gattungen mit etwa 220 Arten gefunden. Folgt dann die Beschreibung von in Japan bekannten Arten von *Ceratiomyxa* (1 Art), *Badhamia* (9), und *Physarum* (10). Die Mitteilungen werden fortgesetzt werden.

**119. Some Japanese Cenozoic plants. I. On the fossil Acer from the Siobara Pleistocene plant beds.** Seidô ENDÔ. (Japan. Jour. Geol. and Geophys. **11**, 1934, 234-253, 8 pls.).

An enumeration of the fossils of *Acer* species in Siobara district, Prov. Simotuke. Altogether 12 species (one with two varieties) are described.

**120. A new species of Nelumbo from the Palaeogene of Japan.** Seidô ENDÔ. (Japan. Jour. Geol. and Geophys. **11**, 1934, 255-257, 3 pls.).

A new species of fossil *Nelumbo*, *N. nipponica* ENDÔ sp. nov. found in several localities of Kyûsyû and Saghalien.

**121. Influence of salt on the pathogenicity of Hypochnus Sasakii SHIRAI.** Sigeru ENDÔ. (Trans. Tottori Soc. Agric. Sc. **4**, 1933, 362-367).

It is well known that the *Sclerotium* disease of rice plants caused by *Hypochnus Sasakii* only rarely occurs in the rice-fields situated near sea.

Experiments were done by the author by inoculating the fungus in sand put in ERLÉNMEYER's flask or in pot soil, to which the solution of common salt of various concentrations was added. Cleaned seeds of rice were sown there after two or three days. It was ascertained that when the concentration of salt solution is 1% upwards the disease never breaks out, and when it is beyond 5% no germination of seeds takes place.

**122. Studies on the antagonism of microorganisms. IV. Growth and pathogenicity of *Sclerotium oryzae-sativae* SAWADA in the presence of other organisms (With Japanese résumé).** Sigeru ENDÔ. (Bull. Miyazaki Coll. Agric. and Forest. No. 5, 1933, 51-75).

Continuation of the author's study since several years (cf. Japan. Jour. Bot. 6, (64), Nos. 219-220). In this paper the antagonistic influence of *Sclerotium oryzae-sativae* on the other fungi and the bacteria is reported. A great number of *Aspergillus* and some others were seen to be antagonistic on culture media to the growth of *Sclerotium oryzae-sativae*, for their mycelia cover the colony of the latter to retard its growth. So it was the case with a great number of *Bacillus* which also impeded greatly the growth of *Sclerotium oryzae-sativae*. Certain species of *Penicillium*, *Mucor* and *Bacillus* have no effect upon *Sclerotium*, inasmuch as they are covered up by the growing mycelium of the latter.

**123. Einfluss der Temperatur auf den Ausbruch der Sklerotienkrankheit der Saubohnen.** (M. japan. Zfg.). Sigeru ENDÔ. (Bull. Miyazaki Coll. Agric. and Forest. No. 6, 1934, 85-92).

Die Intensität des Ausbruches der durch *Hypochnus centrifugus* verursachten Sklerotienkrankheit von *Vicia faba* ist von dem herrschenden Temperaturzustande abhängig, da eine Minimuminfektion bei 10-18°C stattfindet und die Intensität der Infektion allmählich mit der steigenden Temperatur vergrössert.

**124. A new sclerotium disease of *Echinochloa crus-galli* BEAUV. subsp. *submutica* HONDA var. *typica* caused by *Sclerotium fumigatum* NAKATA.** (Japan. with English résumé). Sigeru ENDÔ and Syôzô SAKITA. (Trans. Tottori Soc. Agric. Sc. 4, 1932, 106-110, 2 figs.).

*Sclerotium fumigatum* which causes the sclerotial disease of rice, etc. was found to cause the same disease in the grass cited in the above title. Inoculation experiments gave positive results.

**125. Plants susceptible to dwarf disease of rice-plant.** Teikichi FUKUSHI. (Trans. Sapporo Nat. Hist. Soc. 13, 1934, 162-166).

It is well known that certain virus diseases are transmitted by the agency of some leafhoppers. The author tried to study experimentally the transmission of dwarf disease of rice by the agency of the leafhopper, *Nephotettix apicalis* var. *cincticeps*. It was found that *Panicum miliaceum*, *Echinochloa crus-galli* BEAUV. subsp. *colona* var. *edulis* HONDA, *Alopecurus fulvus* and *Poa pratensis* are subject to the attack of the virus of the rice-plant. But corn, Italian millet, barley and *Sorghum* gave negative results, so far as the author's experiments have shown. These plants are inappropriate as food of the leafhoppers, for the latter could live on them simply for 15 days to die sooner or later.

**126. Studia orchidacearum japonicarum I. Orchidaceae formosanae novae atque criticae.** (With Japan. résumé). Noriaki FUKUYAMA. (Bot. Mag. Tôkyô 48, 1934, 297-308, 1 fig.).



The following new species are described: *Platanthera transnokoensis*, *Habenaria Hosokawae*, *Epipactis Ohwii*, *Gastrodia taiwaniana*, *Collabium uraiensis*, *Calanthe fimbriato-marginata*, *Acanthephippium unguiculatum*, *Cymbidium tortisepalum*, *Luisia cordata*, *Cystopus humilis*.

**127. Relations between length and width suggesting volume constancy in the under cell of teliospores of onion rust.** Kazuo GOTO. (Ann. Phytopathol. Soc. Japan **3**, 1934, 22-36, 8 graphs).

The author has performed the biometric study on the under cell of the two-celled teliospore of onion rust collected from various localities. The shape of this cell is very variable, and the index length/width varies between 0.6 and 2.8-4.4, and yet by the application of a hyperbolic equation (L-2)  $(W-3)^2 = C$ , where L and W denote the length and width of the cell respectively and C is a constant, the author has proven the existence of the relation of volume constancy which is of course subject to small variation, thus the smallest number was 2095 and the largest 2759. So that notwithstanding the great variability of length and width of cell, its plasmic volume is approximately constant. For the occurrence of this constancy the author adduces the following reasons, viz. (1) during the teliospore-formation the total effect of all factors which influence it must have been carried on relatively constant within each material, and (2) the shape of the teliospore is inferred to be a resultant of equilibrium between in- and outside forces, at the same time to be the characteristics of the organism itself.

**128. Observations on the morphological variability of bacteria. I. On amorphous mass-formation.** (Japan. with English résumé). Yukio GOTÔ. (Bull. Japan. Soc. Scientific Fish. **3**, 1934, 25-30, 7 text-figs.).

In hanging drop culture of certain bacteria, viz. *Flavobacterium* and some others, the author observed the amorphous mass-formation which results from the agglutination and subsequent fusion of a number of bacteria individuals; the latter are either the descendants of a single cell or those from several parent cells. In such amorphous mass the author could see the budding out of minute particles which will soon after assume the original bacterial form.

**129. On the karyotypes and their gametes of *Paris quadrifolia* L. var. *obovata* TIL.** (A preliminary note). (Japanese with English résumé). Tutomu HAGA. (Bot. Mag. Tôkyô **43**, 1934, 241-248, 13 text-figs.).—**The comparative morphology of the chromosome complement in the tribe Parideae.** Tutomu HAGA. (Jour. Fac. Sc., Hokkaido Imp. Univ. Ser. V (Bot.) **3**, 1934, 1-32, 1 pl. and 24 fig.-groups).

The number and shape of the chromosome in three species of *Trillium* and three species of *Paris* were observed. Though the chromosome number may be  $n = 5$ , 10 or 20,  $2n = 10$ , 20 or 30 respectively in different species studied by the author, he could distinguish on the whole five kinds of chromosome types, characterized by their length and point of constriction, which he calls A, B, C, D, and E respectively. In the genome of each species every type, viz. A, B, C, D and E is represented 2-8 times, and according to the difference of the times of this repetition that of chromosome

number in each species will result, thus *Paris japonica*  $n = 20$ ,  $2n = 40 = 8(A+B+C+D+E)$ , *P. quadrifolia* var. *obovata*, *P. tetraphylla*, *Trillium kamtschaticum*  $n = 5$ ,  $2n = 10 = 2(A+B+C+D+E)$ , *Trillium Smallii*, *T. Tschonoskii*  $n = 10$ ,  $2n = 20 = 4(A+B+C+D+E)$ .

The above results lead the author to think that the formation of polyploids in the tribe Parideae might possibly be due to the intra- or interspecific hybridization of plants in the present or former times.

**130. Observationes ad plantas Asiae Orientalis II.** (With Japan. résumé). Hiroshi HARA. (Jour. Japan. Bot. **10**, 1934, 227-237, 4 figs.).

The following new species are described among others: *Pleuropteropyrum Nakaii* and *Frilipendula yezoensis*.

**131. Chromosome number of some species in *Polygonatum*.** (Japanese). Nobumi HASEGAWA, (Bot. Mag. Tôkyô **47**, 1933, 12 text-figs.).

Both gametic and sporophytic, or only the gametic number of chromosomes were determined in *Polygonatum japonicum*, *P. humile*, *P. lasianthum*, *P. silvaticum* and *P. falcatum*. These numbers are 10 and 20 respectively, except in the last species, where they are 9 and 18 respectively.

**132. A cytological study on the eight-chromosome rye.** (Japanese). Nobumi HASEGAWA. (Japan. Jour. Gen. **9**, 1934, 97-99).

The gametic chromosome number of *Secale cereale* is generally 7, but rarely 8. According to GOTOH this surplus chromosome should have been derived from the smaller segment of the largest chromosome in the 7-chromosomic rye by its being transversely cut at its constriction part, whence the genome of the 8-chromosomic rye should be  $6+l+k$ , where  $l$  and  $k$  represent the larger and smaller segments derived from the largest chromosome respectively.

The author, in studying the mitosis in the pollen cell, has found almost always besides 7 chromosomes which are quite similar to those in the 7-chromosomic rye the one called  $x$  which is very small and is constricted at its subterminal part into one long arm and one ellipsoidal head. This small chromosome which is  $6.3\mu$  in length is always longer than any arm of the chromosome furnished with a trabant. The results of this study, together with those of LEWITSKY who has observed that the  $x$ -chromosome is longer than any part of the other constricted chromosome, has led the author to the conclusion that this small chromosome  $x$  is different from the chromosome of GOTOH above indicated, so that the genome of the 8-chromosomic rye should be  $7+x$  instead of  $7+k$ , as GOTOH thinks.

**133. List of plants susceptible to mosaic and mosaic-like diseases.** (With Japan. résumé). Iwao HINO. (Bull. Miyazaki Coll. Agric. and Forest No. **5**, 1933, 97-111).

A list of cultivated plants susceptible to mosaic and mosaic-like diseases much prevalent in Japan published by the author contains the names of those known after

the publication of KUNKEL in 1928. The summary of this list is as follows: 298 plants susceptible to diseases above indicated, mostly herbaceous, are enumerated in the list, of which 98 are found in Japan.

**134. Physiological studies on soil Ciliates.** Iwao HINO. (Bull. Miyazaki Coll. Agric. and Forest. No. 6, 1934, 19-84, 1 pl.).

According to the author the Ciliates are of great significance for plant life for the following reasons; (1) they promote the action of nitrogen fixation of *Azotobacter*, (2) they decrease soil acidity, and (3) they destroy plant pathogens in soil. The author has first of all studied the influence of external factors on the reproduction rate of the Ciliates: (1) some nutriments in soil inhibit their growth and even induce their death, the effect of different nitrogen compounds being variable, though that of different carbohydrates is similar, (2) we may distinguish the maximum, optimum and minimum temperature, (3) water content of soil seems to have no effect. Between the bacteria and Ciliates both symbiosis and antagonism are observed.

Usually the Ciliates do not cause the great diminution of soil bacteria, because they are not numerous and cystic throughout the larger part of their life, but they are abnormally abundant under unusual soil condition, e.g. in greenhouse, sewage farm and irrigated field. Then the bacterial number is greatly diminished by the great activity of voracious Ciliates and this leads to poor growth of crops.

**135. On compensation point of woody plants.** Keinosuke HIRAMATSU. (Sc. Rpts. Tôhoku Imp. Univ. 4th Ser. (Biol.) 9, 1934, 70-77).

The compensation point, i. e. the minimum light intensity in which the production of CO<sub>2</sub> by respiration is equal to its consumption by assimilation was determined on a certain number of woody plants which grow in Northern Japan. First the method of experimentation is described and then the results are given.

The light value of the compensation point in summer-green plants and also needle- and broad-leaved evergreen plants is generally over 1000 meter candles. In *Rhus javanica* it is so high as 2000 m. c. while in other summer-green plants (e. g. *Phellodendron amurense*, *Clethra barbinervis*, *Cornus controversa*) and needle-leaved plants, such as *Cryptomeria japonica*, the light value reaches scarcely 1000 m. c., though always above 800 m. c. In *Ginkgo biloba* and *Magnolia praecocissima* (both sun-plants) the light value is low and nearly 700 m. c.

The light value is, so far as the author's experiments have shown, always under 500 and almost 400 m. c. in *Aucuba japonica*.

**136. On some new species of Milesina.** (With Japan. résumé). Naohide HIRATSUKA.

A description of the following new species: *Milesina Hashiokui*, *M. blechnicola*, *M. Faulliana*, *M. microspora*, *M. Diplazii*, *M. Coniogrammes*, *M. Odontosoriae*.

**137. Physiological studies on Uromyces Fabae, f. sp. Viciae-Fabae.** (With Japan. résumé). Naohide HIRATSUKA. (Bot. Mag. Tôkyô 48, 1934, 309-325, 4 figs.; 361).

In *Uromyces Fabae* (PERS.) DE BARY f. sp. *Viciae-Fabae* parasitic on *Vicia Faba* and *Pisum sativum* the best condition for the germination of uredospore and development of germ-tubes lies between 16–22°, 5 C, either in dark or under light. Under 20–22°C the germ-tube was developed after 50–60 min. and attained 560  $\mu$  in length after 12 hours. The germination of spores may take place in the solution of various kinds of sugar. The germination power of spores is lost under 46°C within 20 min. in humid condition, etc. As to other details cf. the original.

**138. Uredinales collected in Formosa.** (With Japan. résumé). Naohide HIRATSUKA and Yoshio HASHIOKA. (Bot. Mag. Tôkyô **48**, 1934, 233–240, 1 fig.-group).

The following new species are described among others. *Uromyces Ligulariae*, *Puccinia nitakensis*, *Ravenelia Milletiae* and *Uredo taiwaniana*.

**139. Studies on the anaerobiosis of plant disease fungi. A comparative study of the anaerobic respiration of the fungi.** Shigekatsu HIRAYAMA. (Mem. Coll. Agric., Kyoto Imp. Univ. No. **30**, 1934, 1–17, 2 figs.).

As the materials of his study on the alcoholic fermentation the author has used 23 species of Japanese fungi known as plant pathogens. They were grown on the PFEFFER's nutrient medium containing 5% glucose, and the quantity of CO<sub>2</sub> evolved was volumetrically measured. According to the results of his investigations the fungi used for his study are mostly able to execute the anaerobic respiration except *Piricularia oryzae* and *Pythium de Baryanum* which are incapable of fermenting glucose under this condition. *Fusarium* sp. No. 7 (the tuber rot fungus of potato), *F.* sp. No. 13 (pathogen of watermelon wilt), *Gibberella Fujikuroi* and *Colletotrichum Spinaciae* show the strongest fermentative activity, while others were observed to perform only weak fermentation.

**140. A life-cycle of *Sphaerotheca fuliginea* (SCHLECHT.) POLLACI parasitic on *Taraxacum ceratophorum* DC.** Yasu HOMMA. (Trans. Sapporo Nat. Hist. Soc. **13**, 1934, 173–188).

In *Sphaerotheca fuliginosa* the conidia are successively produced from a single spore mother-cell formed at the end of the conidiophore. The writer could trace the formation of the antheridium and ascogonium on the hyphae derived from a single conidium. Their form is similar to that seen in other species of *Sphaerotheca* hitherto investigated by various authors. The antheridial nucleus divides into two, of which one or rarely both migrate into the ascogonium. The copulation of antheridial and ascogonial nuclei was observed.

In the youngest ascus the writer observed a large nucleus which in its first division shows clearly eight chromosomes. Eight ascospores are formed as usual. The artificial infection by the conidia as well as ascospores gave positive results.

**141. Nuntia ad florae japonicae XXII.** (With Japan. résumé). Masaji HONDA. (Bot. Mag. Tôkyô **48**, 1934, 406–407, 422–433).

*Rubus isensis* and *Euphorbia Tsukamotoi* are new species. Some new varieties are also recorded.

**142. The bryological flora of the Northern Kurile Islands.** Yoshiwo HORIKAWA. (Bull. Biogeogr. Soc. Japan **4**, 1934, 335-338).

14 species are announced which belong to the Marchantiaceae, Bryaceae, Mnieceae, Bartramiaceae, Amblystegiaceae and Polytrichaceae.

**143. Monographia hepaticarum australi-japonicarum.** Yoshiwo HORIKAWA. (Jour. Sc. Hiroshima Univ. Ser. B, Div. 2 (Bot.) **2**, 1934, 101-325, 11 pls., 63 text-figs.).

This monograph consists of the enumeration and description of the species of the Hepaticae mostly collected by the author himself during the years 1930-1934 in Southern Japan, incl. Formosa, Liukiu Isl., Yakusima Isl., Bonin Isl., Torisima Isl. and Hatizyôzima Isl. The species enumerated in this monograph is 301 in all, of which 107 are new species belonging to 84 genera and 21 families. The results of this monographic study has led the author to the following general conclusions. The hepatic flora of Southern Japan is closely related on the one hand to that of Indo-Malaya, Himalaya and South China, and on the other to that of Japan Proper. Thus, for instance, 50% of the species enumerated by him were already recorded from Japan Proper, while 98% of the genera are represented in Indo-Malaya, Himalaya and South China, as compared with 83% of Japan Proper. The number of endemic species is 36% in Formosa, 24% in the Bonin, 13% in Yakusima, 8.5% in Liukius, 3.7% in Hatizyôzima, and 0% in Torisima. The almost total absence of Philippine elements is remarkable. The species in alpine region of Formosa and Yakusima include the elements of the boreal region, North-eastern Asia and the Japanese Alps.

**144. On the artificially induced mutations and polyploid plants of rice occurring in subsequent generations.** Kichitaro ICHIJIMA. (Proc. Imp. Acad. **10**, 1934, 388-391, 10 text-figs.).

Seeds of various strains of rice soaked in water of 28°C for 24-48 hrs. were subjected to the action of X-ray, ultra-violet ray and temperature variation. Some mutants have appeared already in  $F_1$ , while others were seen first in  $F_2$  or  $F_3$ . Mutational characters are the height of plants (dwarf, miniature), the characters of ear, leaf, spikelet, the sterility of various degrees, and the time of ripening (early ripening).

The change of chromosome number was also induced, viz. heteroploid ( $2n+1=25$ ), triploid ( $3n=36$ ), and tetraploid ( $4n=48$ ).

**145. The deficit of rootless segregates in *Pharbitis Nil*.** Yoshitaka IMAI. (Japan. Jour. Gen. **9**, 1934, 139-142).

A mutational form of *Pharbitis Nil* without rootlets due to a recessive gene has appeared during the author's culture experiment. In the  $F_2$  offspring derived from its cross with the normal strain the author has observed a considerable deficit of rootless plants instead of the expected ratio 3:1. This deficit is due to the certation between the pollen of rootless and normal plants, whereby the pollen-tube of the former grows much slower towards the ovule than the latter. This fact was experimentally proved by using the well known method of HERIBERT-NILSSON.



**146. Analysis of the chromosome-groups in *Lycoris squamigera* MAXIM.** (Japanese). Sukeo INARIYAMA. (Jour. Nat. Hist. **31**, 1933, 3 pp. and 3 text-figs.).—**Phylogeny of *Lycoris* on the karyological viewpoint.** (Japanese). Sukeo INARIYAMA. (Proc. 9th Cong. Jap. Assoc. Adv. Sc. 1933, 342-347, 10 text-figs.).

Two papers cited in the above title contain partly the correction of the author's former paper (cf. Japan. Bot. **5**, (93), No. 316). Except in *Lycoris sanguinea* and *radiata* which contain simply rod-shaped chromosomes, all other species studied by the author, viz. *L. albiflora*, *aurea*, and *squamigera* are characterized by possessing besides rod-shaped ones the so-called V-shaped ones (V-, S-, etc. shaped), i. e. those constricted at a certain part (two-armed) and having the double length of the former. In all such species we see in the meiosis the conjugation of both kinds of chromosomes to each other. Thus, for instance, in *L. albiflora* 5 trivalents are formed, each being composed of 1 V-shaped chromosome and 2 rod-shaped ones attached to the latter, and besides 1 bivalent made of 2 rod-shaped ones. In *L. squamigera* we observe 3 tetravalents, each composed of 2 V-shaped and 2 rod-shaped chromosomes, and besides 5 trivalents, each made out of 3 rod-shaped ones.

Since in the species where both rod-shaped and two-armed chromosomes are seen during the meiosis, two kinds come to conjugation, it may be inferred that they are homologous to each other, so that it will be reasonable to think that each two-armed chromosome is a compound one made out of 2 rod-shaped ones. And then we may question, whether the two-armed or the rod-shaped chromosome is more primitive (i. e. whether 2 rod-shaped chromosomes are fused to one two-armed, or inversely one two-armed chromosome has broken out into 2 rod-shaped ones), whereabout the author thinks the latter alternative to be more probable.

**147. Über die Ei- und Keimentwicklung bei *Fucus evanescens*.** (Japanisch). Shunpei INOH. (Rep. Sta. Alg. Res., Fac. Sc. Hokkaido Imp. Univ. Nr. **3**, 1934, 51-60, 2 Taf. u. 1 Textabb. gruppe).

*Fucus evanescens* ist monözisch. Die Eier und Spermatozoiden, welche bald nach ihrer Reifung nacheinander ausgestossen zu werden scheinen, zeigen dabei keine Periodizität. In der einkernigen Eimutterzelle erfolgen nacheinander eine heterotypische (Reduktions-) und zwei homöotypische Kernteilungen, wodurch acht Eizellen ausgebildet werden. Bei der heterotypischen Kernteilung ist an einem Ende der Eimutterzelle, unmittelbar aussen der Stelle des Kernes, wo der synaptische Chromatinfaden angesammelt ist, eine Aster mit einem punktförmigen Zentrosom nachweisbar. Nachdem zum Ende des Spiremstadiums der Chromatinfaden zu einer Anzahl von Fäden zerfallen ist, beobachtet man an zwei Polen des Kernes je eine Aster mit einem Zentrosom. Beim letzten Diakinesestadium, wobei man in dem Spindeläquator 32 bivalente Chromosomen findet, beginnt jedes Zentrosom sich durchzuschnüren, und bei der Metaphase teilt er sich zu zwei Tochterzentrosomen. Die Eispore teilt sich vor allem zu zwei Zellen, von denen die untere bald eine Teilung erfährt und zur Ausbildung einer Rhizoidzelle kommt. Die letztere ist durch die Tatsache ausgezeichnet, dass sie niemals an ihrem unteren Ende verzweigt, im Gegensatz zu dem, was man bei *Ascophyllum*, *Pelvetia* usw. sieht (vgl. Japan. Jour. Bot. **6**, (35), Nr. 117 oder (100), 357).

Zum Ende weist der Verf. auf die Kleinheit des Eies bei *F. evanescens* hin und er gelangt zur Verallgemeinerung, dass die Eikleinheit und die Nichtverzweigung der Rhizoidzelle zueinander korreliert sind.

**148. Meiosis in pollen mother-cells of *Linum usitatissimum*.** (Japanese with English résumé). CHOYO INOUE. (Proc. Crop Sc. Soc. Japan **6**, 1934, 280-287, 1 pl.).

In the meiosis of the pollen mother-cells in *Linum usitatissimum* the nucleolus produces two or more secondary nucleoli in the synapsis stage, and the spirem is connected with the nucleolus at one point through them. At the late pachytene stage the spirem seems to lose gradually its chromatin, and enters into colourless stage, so-called achromatic stage. At the beginning of the first telophase the movement of chromatin from the chromosome takes place along the fine threads to form irregular chromatin masses, which will become a new nucleolus. During the second prophase the same process as in the first prophase and the telophase is repeated, i.e. the transfer of chromatin from the nucleolus to the chromosome and the reverse respectively.

**149. Occurrence of speltoid mutants in some Japanese varieties of wheat I-II.** (Japanese with English résumé). KISABURÔ ISIKAWA. (Agric. and Hort. **9**, 1934, 1361-1371, 5 figs.; 1556-1571, 2244-2247, 4 figs.).

The spontaneous development of speltoid mutants in the pure strain of the Japanese varieties of *Triticum vulgare* has often been observed. They are heterozygotic at first, and their segregation may give rise besides their own type normals, homo-speltoids, compactoids and dwarf compactoids, though the mode of segregation is different in different varieties. The mutation percentage observed till now lies between 0.08 and 0.3%. Mosaics were often found in the progeny, for example, normal+speltoid, speltoid+compactoid, awned+awnless, etc.

**150. Investigation on the influence of earth-circuit on the biological activities.** ARATA ITANO. **I. Influence on *Azotobacter chroococcum*.** (Proc. Imp. Acad. **9**, 1933, 47-50; Ber. Ôhara Inst. landw. Forsch. **6**, 1933, 42-47, 1 pl. and 1 fig.).—**II. Mechanism of the potential.** (Proc. Imp. Acad. **9**, 1933, 309-312, 1 fig.; Ber. Ôhara Inst. landw. Forsch. **6**, 1933, 48-52, 1 pl. and 2 figs.).—**III. Mechanism of the influence on *Azotobacter chroococcum* as to its electrophoresis.** (Proc. Imp. Acad. **9**, 1933, 592, 2 figs.; Ber. Ôhara Inst. landw. Forsch. **6**, 1934, 255-257, 1 pl. and 1 fig.).

Ad I. The biological investigations have been done hitherto mostly independently of the aerial-earth circuit, i.e. under the insulated condition. The author has described his investigations on *Azotobacter chroococcum* under the influence of aerial-earth circuit. This microorganism was cultured in ASHBY'S medium, and the whole was placed under the complete aerial-earth circuit, the medium being connected to the antenna or to the earth, and the result was compared with that of the control. The results are as follows. In the complete circuit *Azotobacter chroococcum* grows much more vigorously and is able to fix much more nitrogen than in the control. This beneficial influence is seen even when this connection is with the earth only, though not as great as when the circuit is complete, but not at all, when the connection is to the antenna only.

Ad II. The electric potential of the culture of *Azotobacter chroococcum* and that of the sterile culture were compared to each other. The flask containing ASHBY's medium was connected either to the earth or antenna or to both, or not at all. The slight increase of potential was observed in all cases, except in the last one. Similar experiments were made on flasks containing the culture of *Azotobacter chroococcum* in the same medium. In some the decrease of potential occurred while in others the negative potential was detected.

Ad III. A strain of *Azotobacter chroococcum* which was cultured in ASHBY's liquid medium with or without the addition of  $\text{CaCO}_3$  was placed under the influence of the aerial-earth circuit, either open or closed. The electrophoresis is summarized as follows. *Azotobacter chroococcum* being negatively charged migrates towards the anode, of which the velocity is a little depressed by the presence of excess of  $\text{CaCO}_3$  in the medium. In the closed circuit this velocity is depressed in both media, either with or without  $\text{CaCO}_3$ .

**151. Studies on the influence of ultra-violet rays on the physiological activities of *Azotobacter* I. On the lethal action.** (Japanese and English). ARAO ITANO and AKIRA MATSUURA. (Agric. Studies **23**, 1934, 309-326; also Ber. Ōhara Inst. landw. Forsch. **6**, 1934, 383-392, 3 figs.).

The authors have studied the influence of ultra-violet rays on *Azotobacter chroococcum* by using the mercury lamp of HANOVIA. The variation of the intensity of ultra-violet ray during the experiment was so, that the discolouration of acetone methylene blue was 3.0-2.5 after one hour, and by the molybdic acid method aH (activated hydrogen) was 2.1-1.6 after 10 min. Though the intensity of ultra-violet rays is variable according to the distance between the light source and the object of which the influence of rays is to be studied, yet in the authors' experiment the difference of the intensity in different distances was not very great. The plate culture of *Azotobacter* in PETRI dish of hard glass does not die after 2 hours; that in "Acme" ultraviolet glass for 1 hour grows very weakly and dies after 2 hours, while that with no cover dies after 30 seconds. The liquid media culture in quartz test-tube dies after somewhat more than 5 minutes, the number of bacteria being greatest after 5 seconds, even greater than in the control. In liquid media culture in ordinary ERLENMEYER's flask of hard glass we see the decrease of the individual number, the quantity of fixed nitrogen as well as of pH, but not the death. Both in plate and pure culture the exposition of bacteria to ultra-violet ray for a short moment stimulates their activity.

**152. Studies on the nodule bacteria of *Astragalus sinensis* (Genge).** ARAO ITANO and AKIRA MATSUURA. (Ber. Ōhara Inst. landw. Forsch. **6**, 1934, 259-267).

*Astragalus sinensis* (Japanese name Genge) is widely used in Japan as green manure in paddy fields. Concerning the bacteria cultured in PETRI dish the distance of their migration under various moisture conditions was observed by placing diametrically a glass rod with the measurement within the dish. It was found that the rate of migration was largest under 18% moisture; it may take place under the moisture as high as 26%, but not below 5%. The positive chemotaxis was observed especially towards the germinating seeds of *Astragalus sinensis*. The influence of

the addition of NaCl was studied, and it was found that 0.01-0.5% is best for bacterial growth, and above 4% is detrimental. Even in paddy fields and dry farms, when *Astragalus* has been cultivated previously, the inoculation of bacteria has given the better results concerning the quantity of crop and total nitrogen as well as the number of nodules.

**153. On the root-tubercle bacteria in the Leguminosae III-IV.** ARAO ITANO and Akira MATSUURA. (Japanese). (Agric. Studies **22**, 1934, 218-268, 1 text-fig.; ibid. **23**, 1934, 294-308).—**Studies on the nodule bacteria of *Astragalus sinensis* (Genge). III. Fermentation of carbohydrates with special reference to the carbon and hydrogen source.** ARAO ITANO and Akira MATSUURA. (Ber. Ôhara Inst. landw. Forsch. **6**, 1934, 341-381).

Experiments were done on three different strains of the root-tubercle bacteria of *Astragalus sinensis* cultured either on liquid or solid media. They are shortly rod-shaped, and are provided with a polar flagellum. They perform the acid fermentation, in which the monosaccharides, i.e. arabinose, xylose, glucose, galactose, mannose are generally most suitable as materials, but not the polysaccharides. Different monosaccharides show the difference in this respect, thus, for instance, glucose, xylose, mannose, etc. are the best, while arabinose and galactose are mediocre. Nitrogen is necessary for the performance of acid fermentation, though not essential for growth. As the source of nitrogen for this process  $\text{NH}_4$ ,  $\text{SO}_4$ ,  $\text{NH}_4\text{Cl}_2$ , peptone,  $\text{KNO}_3$ ,  $\text{NaNO}_3$  are suitable in descending order. The behaviour of three strains used by the author in his experiments during acid fermentation towards various saccharides is characteristic of each, so that it may serve as the basis of the systematic classification of root-tubercle bacteria in general.

Experiments were done further concerning the influence of ultra-violet rays upon the strains of bacteria above indicated. Though they die only within 30 seconds by the action of direct ultra-violet rays, their death follows only after one hour by the rays passing through the light filter of HANOVIA's mercury lamp. Also one or one-half hour passes before their death when they are put within the PETRI dish of hard glass or within ultravit glass respectively. When in this experiment ordinary test-tube of hard glass is used the strains B and C on one side and A on the other die after 20 and 30 minutes respectively, while when quartz tube is used, all three strains die within one minute. When they are covered with sand layer 1/2 cm thick they do not die even after 5 hours, while when sand is 0.25 cm thick only the B strain dies after 5 hours, and the A can survive only for a little while. Under natural light of very fine weather the limit between life and death of bacteria lies at 30 minutes. Under natural light the soil bacteria were observed to diminish considerably after 30 seconds. Since the bacteria are much more sensible to the influence of ultra-violet rays than the moulds, the rate of decrease of the former under their influence is much greater both in paddy and dry farms. The continual action of ultra-violet rays for three hours is not sufficient to destroy the moulds and bacteria there entirely.

**154. Cytological studies on the genus hybrids among *Triticum*, *Secale* and *Aegilops*, and the species hybrids in *Aegilops*.** FUYUWO KAGAWA and Yoshiwo CHIZAKI. (Japan. Jour. Bot. **7**, 1934, 1-32, 90 text-figs.).



**155. Studies on the artificial pollination of watermelon.** (Japanese). Takesi KANDA. (Materials for the Improvement of Agric. **81**, 1934, 111-116).

The author who lives in Prov. Yamato, the region well known by the production of excellent watermelons, has performed the studies reviewed below. In the first days of July, when the weather is fine, the flowers of watermelons were observed to begin to open at 4 o'clock a.m., and to shut wholly at 8 o'clock p.m.; the anthers burst and discharge abundant quantity of pollen between 5½-6 o'clock a.m. In nature watermelons are pollinated almost wholly by honey bees. In the case of artificial pollination it must be performed before 9 o'clock a.m., otherwise the harvest will be considerably diminished, even below 50%. The fertilization between female and male flowers which have opened in different days is without effect.

**156. New or noteworthy trees from Micronesia V-VI.** (With Japan. résumé). Ryôzô KANEHIRA. (Bot. Mag, Tôkyô **48**, 1934, 111-130; 8 figs.; 163-164; 400-405, 2 figs., 421-423).

The following Pandanaceae are recorded as occurring in the Caroline and Marianne Islands. The determination is due to Ugolino MARTELLI, Florence.: *Pandanus duriocarpus* sp. nov., *P. fragrans*, *P. Kanehirae*, *P. ponapensis* sp. nov., *P. macrojeanneretii* sp. nov., *P. palauensis* sp. nov., *P. aimirikiensis* sp. nov., *P. patina* sp. nov., *Freycinetia Villalobosensis* sp. nov., *F. ponapensis* sp. nov.

The following new species are described with illustrations: *Drypetes nitida*, *D. dolochocarpa*, *Calophyllum Wakamatsui*, *Boerlagiodendron pachyllum*, *B. truncatum*, *Mada palauensis*.

**157. Haploid formation by X-rays in *Triticum monococcum*.** Yoshiwo KATAYAMA. (Cytologia **5**, 1934, 235-237, 2 fig.-groups).

The haploid formation in *Triticum monococcum* occurred most frequently (nearly 18%), when normal pistil was treated by pollen taken on the plant, of which spikes with ripe pollen were X-rayed, while the pollination of X-rayed pistil by normal pollen has given no haploids. The author considers that some male nuclei derived from pollen or its mother-cell which was X-rayed comes to degeneration without fusing with the egg nuclei, and the stimulation of male nuclei may have activated eggs to parthenogenetic development.

**158. On the preservation of potato pollen.** Kôzirô KAWAKAMI. (Agric. and Hort. **9**, 1934, 2012-2016).

The duration of viability of potato pollen under the relative humidity varying from 0-60% was studied. 15-20% humidity seems to be the best for the purpose, for the pollen was viable even after 14 days and able to cause certain fruit setting. Under the relative humidity higher or lower than the above indicated the duration of the preservation of fertilizing power of pollen is shorter.

**159. Bacterial blight of chestnut.** (Japanese with English résumé). Eikichi KAWAMURA. (Ann. Phytopathol. Soc. Japan **3**, 1934, 15-21, 2 pls.).



The symptom of blight disease of chestnut which though most conspicuous in buds and young shoots, may appear in many other parts, is characterized in its early stage by the appearance of water-soaked spots on leaves and young shoots, where the cortical parenchyma is destroyed to form hollow cavities and brown cracks. White and yellow bacteria were isolated, and the former proved to be the causal organism of the disease. It is a new species, *Bacterium Castanae*.; its diagnosis is given which is based as usual upon morphological, cultural and physiological characters.

**160. Genetische Studien an gestreiften Sippen von *Celosia cristata* L. II.** (Japanisch). Hitoshi KIHARA. (Japan. Jour. Gen. **9**, 1934, 125-127).

Fortsetzung des früheren Versuches (vgl. diese Zeit. **6**, (37), Nr. 124). Früher war es nachgewiesen, dass die Wirkung des für die Streifung verantwortlichen Genes *a* durch einen Allelomorph *a<sup>k</sup>* stark geschwächt wird, was der Verf. jetzt die Stabilisierung des Streifungsgenes nennt. Die späteren Versuche haben die Resultate der früheren bestätigt. Auch hat der Verf. die Tatsache experimentell nachgewiesen, dass das Gen *a* für selbst das Vermögen für Stabilisierung besitzt, obschon dabei die Wirkung viel weniger intensiv ist als dieselbe von *a<sup>k</sup>*.

**161. Die Geschlechtschromosomen von *Humulus japonicus*.** (Japanisch m. deutsch. Zfg.). Hitoshi KIHARA und Isao HIRAYOSHI. (Sep. aus dem Proc. 8th Congr. Jap. Assoc. Adv. Sc. 1932, 6 S. mit 2 Fig. gruppen).

Die Zahlenverhältnisse von weiblichen und männlichen Pflanzen von *Humulus japonicus* bei offener und künstlicher Bestäubung (die letztere mittels reichlicher Pollenmenge) sind 248 ♀ : 202 ♂ bzw. 49 ♀ : 19 ♂, was an die Zertationswirkung zum Gunsten der weiblichen Pflanzen hinweist. Zwei oder drei unter 16 (♀) oder 17 (♂) Chromosomen im ganzen sind als die Geschlechtschromosomen aufzufassen, nämlich 2X bzw. 1X und 2Y. Das X-Chromosom ist gleichschenkelig, während Y<sub>1</sub> und Y<sub>2</sub> ungleichschenkelig sind. Die kürzeren Schenkel von Y<sub>1</sub> und Y<sub>2</sub> sind kürzer als der Schenkel von X, und ausserdem ist der kürzere von Y<sub>1</sub> etwas länger als derselbe von Y<sub>2</sub>. Bei der Prophase der P. M. Z. beobachtete der Verf. die triradiale Anordnung von drei Geschlechtschromosomen, woraus die Homologie der Schenkel von X mit dem langen Schenkel von beiden Y wenigstens am distalen Ende festgestellt ist.

**162. Reifungsteilungen bei dem haploiden *Triticum monococcum*.** (Japanisch mit deutsch. Zfg.). Hitoshi KIHARA und Yoshio KATAYAMA. (Agric. & Hort. **8**, 1933, 17 pp.).

Wenn schon die karyologischen Untersuchungen über verschiedene haploide Pflanzen ausgeführt worden sind, beziehen sie sich meistens an die die Diakinesis folgenden Stadien der ersten Reifungsteilung der P. M. Z. Die Verf. haben in der vorliegenden Arbeit betreffend die haploiden Pflanzen von *Triticum monococcum*, entweder die natürlichen oder die künstlich durch die Wirkung der X-Strahlen produzierten, die Kernverhältnisse, nicht nur bei solchen Stadien, sondern auch bei den früheren studiert. Die Resultate sind kurz wie folgt. In der I. Prophase findet keine Syndese statt. In der Diakinese tritt eine "end-to-end"-Verkettung der

univalenten Chromosomen ein, um eine mehr oder minder grosse Zahl von geschlossenen Ringen auszubilden. Die Zahl der an die Bildung jedes Ringes beteiligten Chromosomen ist variabel. Die P. M. Z. enthalten keine Bivalenten, wenn nicht ganz ausnahmslos. Wenn die Verteilung der Univalenten nach den beiden Polen meistens zufallmässig geschieht, scheint doch die Kombination 3 + 4 etwas häufig zu sein. In der II. Reifungsteilung stimmt die Häufigkeit der Chromosomenzahl in den Tochterzellen mit dem Zufallsverteilung gut überein.

**163. Physiological studies on a wilt resistant strain of flax with special reference to the effect of soil condition.** (Japanese with English résumé). Muneo KIKUCHI. (Proc. Crop Sc. Soc. Japan **6**, 1934, 259-279, 1 pl. and 4 figs.).

A strain of flax highly resistant against the wilt disease caused by *Fusarium lini*, which was bred out from the strain Riga was studied in respect to soil and temperature condition. It was observed that in the original Riga strain the occurrence of wilt disease goes up to 68 or 42% under the low or high soil moisture respectively, while in the new strain it ranges nearly from 0 to 2.1% under the same condition. In respect to the temperature the strain Riga was more or less susceptible than the new strain below 30°C respectively. The optimum lies between 25-30°. Since when the epidermal or subepidermal cells of hypocotyls are plasmolyzed by 0.3-0.5 mol. sugar solution, it was seen that the new strain showed a higher percentage of "Krampf-plasmolyse" than Riga, the author considers that this difference of protoplasmic behaviour between the two strains might have a certain relation to the high resisting power of the new strain.

**164. Enumeratio salicacearum insulis yezoensis, sachalinensis et kurilen-sibus sponte crescentium.** Arika KIMURA. (Reprint from K. MIYABE and Y. KUDO, Flora of Hokkaido and Saghalien IV in Jour. Fac. Agric., Hokkaido Imp. Univ., Sapporo **26**, 1934, 391-452).

Among 50 species in all the following are described.

*Salix aquilonia*, *S. subreniformis*, *S. ketoensis*, *S. Sugawarana*, *S. taraiensis*, *S. Tatewakii*, *S. poronaiica*, *S. Koidzumii*, *S. Kudoi*, *S. nyiowensis*, *S. orotchonorum*, *S. pseudo-paludicora*, *S. pulchroides*, *S. shikotanica*, *S. stoloniferoides*, *S. phanero-dictya*, *S. rashuwensis*, *S. finalis*.

Besides a certain number of new varieties, combinations, etc. are contained in this paper.

**165. Contributio ad cognitionem florae manshuricae II-III.** (With Japan. résumé). Masao KITAGAWA. (Bot. Mag. Tôkyô **48**, 1934, 1-38, 7 figs., 68-78; 91-115, 16 figs., 159-162).

Among the plants enumerated the following are new species. *Carex prevernalis*, *C. subconcolor*, *C. mukdensis*, *Allium Satoanum*, *Disporum flavens*, *Iris typhifolia*, *Melandrium irukutense*, *Raphanus stenocarpus*, *Astragalus Satoi*, *Lespedeza macro-virgata*, *Gentiana manshurica*, *G. Yamatsutae*, *Pycnostelma leucanthum*, *Statice florida*, *Leonurus pseudo-macranthus*.

**165. Compositae novae japonicae VII.** (Avec le résumé japonais). Siro KITA-MURA. (Acta Phytotax. et Geobot. **3**, 1934, 97-111).

Les nouvelles espèces suivantes sont décrites entre autres.

*Artemisia Momiyamae*, *A. debilis*, *Aster ciliosa*, *Carpesium Hosokawae*, *Premathes formosana*, *Saussurea kirigaminensis*, *S. Yoshinagae*, *Taraxacum kimuranum*, *T. kudoanum*, *T. sendaicum*, *T. shimushirense*, *T. variabilis*, *T. ketoense*, *T. tsurumachii*.

Cet article contient outre les nouvelles espèces indiquées ci-dessus un nouveau genre *Takeikadzuchia*, le nom pris de celui d'un dieu en mythologie japonaise.

**167. Bambusaceae novae japonicae.** Gen'iti KOIDZUMI. (Acta Phytotax. et Geobot. **3**, 1934, 68-70).

The following are the new species named by the author himself: *Pleioblastus ryokeana*, *Sasa Yoshinoi*, and *S. Mikawana*. *Sasella Inuii*, *Pleioblastus sedoensis* and *P. hodoensis* by MAKINO are also described besides the above three new species.

**168. On Gigantopteris.** (Japanese). Gen'iti KOIDZUMI. (Acta Phytotax. et Geobot. **3**, 1934, 111-113).

According to the author's opinion *Gigantopteris* of Eastern Asia should be divided into four genera. Firstly, *Gigantopteris* proper, incl. fossils of the type *Gigantopteris nicotianaefolia* found in Upper Dyas of Eastern Asia. Secondly, *Gigantopteridium* gen. nov. including fossils of the type *Gigantopteris americana* found in North America and Asia. Thirdly, *Gigantopteris antiqua* KAWAS. et KONNO found in Lower Dyas. Fourthly, *Gigantopteris Lagrelii* HALLE included among the type of *G. nicotianaefolia* should be rightly belong to *Cathaysiopteris* gen. nov.

According to the author's opinion all these four genera should belong to the Eusporangiateae rather than to the Pteridospermae.

**169. Studies on the Japanese Taraxacum.** (Japanese). Hideo KOIDZUMI. (Jour. Japan. Bot. **9**, 1933, 349-364; **10**, 1934, 29-36; 69-77, 3 fig.-groups, 136-149, 4 fig.-groups, 305-318).

After the enumeration of Japanese literature concerning the Japanese species of *Taraxacum*, often with critical remarks the author goes to his principle of the *Taraxacum* classification. He thinks that it should not be based simply on the morphological characters, as it was usually the case till now, but also the ecological as well as the distributional characters should be taken out into consideration. He discusses in detail such characters, often with plenty of illustrations. Lastly, the author proceeds to the description of all known *Taraxacum* species hitherto recognized with the key for their identification.

**170. Über das Erscheinen der keimlosen und vielkeimigen Reiskôrner, sowie ihre Charaktere und Erblichkeit.** (Japanisch). Mantarô KONDÔ und Shigeo ISSHIKI. (Landw. Studien **22**, 1934, 66-84, 4 Abb.).

Keimlose Reiskörner wurden zu 0,01–0,02% aufgefunden. Ihr Erscheinen ist ganz zufällig und sie sind nicht erblich.

Doppelkeimige Reiskörner, deren Erscheinen nur 0,003% beträgt, ist ebensowenig erblich. Aus jedem solchen Korn werden je zwei Pflänzchen produziert, von denen nur eins weiter entwickeln konnte.

**171. Vergleichende Studien über die Aschenbilder von verschiedenen Arten von *Setaria*, *Panicum*, *Echinochloa* und von den dazu verwandten Arten.** (Japanisch). Mantarô KONDÔ und Yasuo KASAHARA. (Landw. Studien **23**, 1934, 199–242, 43 Textabb.).

Die bei der Unterscheidung der Aschenbilder benutzten Merkmale sind bezüglich den Hüllspelzen die Gestalt der in der Oberhaut vorhandenen quartziferen Zellen (sanduhrförmig oder flach), sowie ihre Verbreitungsweise auf die Blattfläche (über die ganze Fläche zerstreut oder auf den Nerven beschränkt), die An- oder Abwesenheit der polsterartigen Erhebungen sowie der dickwandigen Zellen. Bezüglich der Blütenspelzen sind die An- oder Abwesenheit der Erhebungen an der Oberhaut, die Gestalt der letzteren, sowie die An- oder Abwesenheit der quartziferen oder dickwandigen Zellen an derselben die Unterscheidungsmerkmale. Ein analytisches Schlüssel für die Identifizierung verschiedener Arten, welches auf die oben angedeuteten Merkmale gegründet ist, wird angegeben.

**172. Die Beziehungen zwischen verschiedenen physiologischen Erscheinungen der Pflanzen und den in verschiedenen Vegetationsorganen in Erscheinung tretenden Farbstoffen.** Hiroshi KOSAKA. V. Mitteilung. Über die Beziehungen zwischen dem Dasein des Anthocyanfarbstoffes und der Transpiration bei einigen Kulturpflanzen. (Jour. Dep. Agric., Kyushu Imp. Univ. **4**, No. 2, 1933, 95–126).—VI. Mitteilung. Überblick bisher erhaltener Ergebnisse und Erwägungen über ihre Anwendbarkeit auf praktische Gebieten. (Ibid. **4**, No. 3, 1934, 127–160).

Ad V. Mitteilung. Wenn man die Pflanzen, welche in ihren Blättern und Stengeln das Anthocyan enthalten (z. B. gewisse Varietäten von *Perilla* oder *Oryza*) und dieselben, wobei der Farbstoff in den Blättern ganz fehlt (z. B. *Abutilon avicennae*) hinsichtlich der Transpiration studiert, wird man sehen, dass unter der Besonnung dieser Vorgang sowie seine tägliche Schwankung grösser sind bei den ersteren als bei den letzteren. Unter schwachem Sonnenlicht sind diese Verhältnisse gerade umgekehrt. Die Stärke der Transpiration steht offenbar in inniger Beziehung zu dem Anthocyangehalt der Blätter, insofern als dieser Farbstoff die Wärme absorbiert und diesen Vorgang beschleunigt.

Zu VI. Mitteilung. Dieser Teil enthält die kurze Rekapitulation der vom Verf. in Mitt. I–V beschriebenen Tatsachen, worauf er auf die hohe praktische Bedeutung der physiologischen Untersuchungen des Anthocyanfarbstoffes auf dem Gebiet der Landwirtschaft und Gartenbau hinweist. (Vgl. diese Zeit. **5**, (11), Nr. 29, (99), Nr. 329; **6**, (8), Nr. 25, (104), Nr. 372).

**173. On the life-history of *Monostroma*.** Hiroshi KUNIEDA. (Proc. Imp. Acad. **10**, 1934, 103–106, 12 text-figs.).



The life-history of *Monostroma* was not hitherto elucidated completely, contrary to that of other members of the Ulvaceae, e.g. *Ulva* and *Enteromorpha*. Since the author has got a great number of zygotes of *Monostroma* he has studied their development by means of artificial culture. The zygote which is a green spherical body about  $6\mu$  in diameter has grown gradually during the course of several months of this culture to a thick-walled body about  $33-64\mu$  in diameter. The contents of the latter divide into about 32 cells, each of which is transformed into a long pear-shaped zoospore with four cilia; they are discharged one by one through the pore of the zygote wall. The zoospore soon loses its cilia, and comes to rest, and then it germinates to form finally the young sporeling. The latter will no doubt represent the gametophytic generation which will give rise to gametes. *Monostroma* differs from *Ulva* and *Enteromorpha*, inasmuch as in the former the sporophytic and the gametophytic generation are thus different in their outer character, while in the two latter they are quite similar externally. The author thinks on the basis of his studies above indicated that *Monostroma* seems to have some relation with Chlamydomonadaceae, and should be included among a new family Monostromaceae.

**174. Behaviour of chromonemata in mitosis.** Yoshinari KUWADA and Takeshi NAKAMURA. **I. Observation of pollen mother cells in *Tradescantia reflexa*.** (Mem. Coll. Sc., Kyoto Imp. Univ. Ser. B, **9**, 1934, 129-139, 1 pl. and 3 text-figs.).—**II. Artificial unravelling of coiled chromonemata.** (Cytologia **5**, 1934, 244-247, 1 pl.).—**III. Observation of living staminate hair cells in *Tradescantia reflexa*.** (Mem. Coll. Sc., Kyoto Imp. Univ. Ser. B, **9**, 1934, 343-366, 2 pls. and 1 text-fig.).

Ad I. The facts described in the paper formerly published in Japanese (cf. Japan. Jour. Bot. **6**, (41), No. 137) are written in English in this article, so that the contents are essentially similar, though more detailed in this article than in the former. The chief conclusions are as follows. The double-coiled spirals in the metaphase are not single, but double which is clearly seen by treating them with ammonia vapour and staining by aceto-carmin. In some cases the larger spiral is drawn out, so that the double-coiled chromonema is reduced to the single spiral. In the interkinesis the larger spiral becomes invisible, and the smaller is much deformed. In the homotype prophase a new coiling of chromonemata takes place, as the result of which the old spirals that have reappeared in the spiral stage are drawn out.

Ad II. The pollen mother cells of *Tradescantia reflexa* in the heterotype division imbedded in a sugar solution was treated with ammonia vapour. This treatment has led chiefly to the two types of chromonemata unravelling. In the one the cylindrical spiral with a larger diameter formed of the chromonema spiral of smaller diameter is unravelled with no marked change in respect to the coiled state of the latter, which thus resembles externally the chromonema spiral with matrix or the spireme seen in late prophase in the homotype division. This proves that ammonia vapour acts solely in the matrix of the larger spiral, but not on that of the smaller. In the second type the matrices of both larger and smaller spirals are equally affected by the vapour, so that the general appearance resembles very much that of the nuclei in the interkinesis in which we see a mass of irregularly coiled or sinuously running chromonemata. Be-



sides some transitional forms between the above two types were seen. As to the theoretical discussion drawn from the above results v. the original paper.

Ad III. Young staminate hairs of *Tradescantia reflexa* were observed in living state in liquid paraffin, either under bright or dark field illumination. Through such methods the author was able to trace the behaviour of living chromonemata throughout all stages of chromonema cycle. This was not possible however concerning the stages from the late prophase to early telophase, owing to the fact that they are generally more or less swollen, especially so considerably in the metaphase that no spiral structure was discernible. This structure is most clearly visible in the late telophase and in the beginning of the prophase (called the spiral stage), when the chromonemata are much shrunken. It is also visible equally conspicuously or even more so in the interkinesis.

At the end of this paper the author makes a critical discussion on several views of various authors on the chromosome structure.

**175. *Alabastra diversa* III.** (With Japan. résumé). Fumio MAEKAWA. (Bot. Mag. Tôkyô **48**, 1934, 48-53, 6 figs., 79-80).

*Arisaema atrolingum* sp. nov. is described among others.

**176. Beiträge zur Kenntniss der Flora von SüdJapan. II.** Genkei MASAMUNE. (Trans. Nat. Hist. Soc. Formosa **24**, 1934, 206-214, 1 fig.).

Die folgenden neuen Pflanzen aus Ryûkyû Inseln und Formosa sind beschrieben: *Hayataellis michelloides*, *Burmanniea Urazii*, *Alpinia iriomotensis*, *Microstylis iriomotensis*, *Eulophia Gusukuma*, *Eurya yaeyamensis*, *Adinandra ryukyuensis*, *Frazinus taiwanianus*, *F. Sasakii*, *Mechitidia Odajimae*, *Vanda amiensis*, *Sarcophilus Segawai*, *Phalaenopsis riteiwanensis*.

**177. A list of plants collected in the Island of Kizan.** Genkei MASAMUNE and Sigeoyosi SUZUKI. (Ann. Rpt. Taihoku Bot. Gard. **3**, 1933, 49-75, 3 figs.).

After the introduction concerning the vegetation, the phytogeographical position as well as the composition of the flora of Kizan Isl., a small volcanic island situated in the sea N.E. of Formosa Proper, the plants collected there in July 1932 are enumerated, 288 in all, belonging to 89 families. The following are new and described: *Pteris taiwaniana* and *Microstylis kizanensis*.

**178. Behaviour of chromosomes in triploid *Petunia*.** (Japanese). Hideo MATSUDA. (Proc. Crop Sc. Soc. Japan **6**, 1934, 53-62, 4 fig.-groups).

The cross between large-flowered tetraploid race ( $4n = 28$ ) and ordinary diploid ( $2n = 14$ ) one of *Petunia violacea* has given rise to triploid plants ( $3n = 21$ ). In the first metaphase of the P.M.C. of the latter we observe 2-7 trivalents, either the latter alone or together with some bi- and univalents. The author thinks in this case that the trivalent chromosome is normal, and the bi- or univalent is secondarily derived from the latter by the separation, whence the author comes to the conclusion that the genomes of both parents are the same, and he has here to deal with an autopolyploid.

He further adopts in some cases the hypothesis of partial exchange of chromosome segments to explain his observation.

**179. On the number of spiral gyres in the chromonemata.** (A preliminary note). (Japanese with English résumé). Hajime MATSUURA. (Japan. Jour. Gen. **9**, 1934, 143-149, 1 pl. and 1 text-fig.).

The number of spiral gyres of the chromonemata in the first meiotic metaphase of P.M.C. of *Trillium kamtschaticum* is stable, and the pitch of coils in each chromonema is exactly the same in all five chromosome types of the genome, so that the length of chromosomes is exactly proportional to the number of spiral gyres, i.e.  $l = pn$ , where  $l$  denotes the length of chromosome,  $p$ , the pitch value and  $n$  the number of gyres. Hence further  $L = n \sqrt{(\pi r)^2 + p^2}$ , where  $L$  denotes the total length of coils, and  $r$  the diameter of the chromosome, whence  $L = \sqrt{(\pi r)^2 + p^2} : p$  which was calculated as 7.7:0.79.

**180. On the Potamogeton of the Kurile Islands.** (Japanese). Shigeru MIKI. ("Rikusuigaku Zasshi", Jour. of Studies of Land and Water **3**, 1934, 122-128, 10 figs.).

10 species of *Potamogeton* were hitherto known from the Kurile Isl. One species, *P. pectinatus* was newly added to the list, owing to the expedition of Viscount A. TANAKA. The species mentioned in the author's paper are as follows: *P. alpinus*, *gamineus*, *distinctus*, *Maackianus*, *natans*, *nipponicus*, *pectinatus*.

All are described with illustrations, and the key for determination is given.

**181. On the sea-grasses in Japan. II. Cymodoceaceae and marine Hydrocharitaceae.—III. General consideration on the Japanese sea-grasses.** (With the summary in Japanese). Shigeru MIKI. (Bot. Mag. Tôkyô **48**, 1934, 131-142, 7 figs.; 171-219).

Continuation of the author's former paper concerning *Zostera* and *Phyllospadix* (v. this Jour. **7**, (13), No. 52).

Three species of *Cymodocea* are known from Japan, viz. *serrulata*, *rotundata* and *isoetifolia*. They are dioecious, and so far as known till now, they are destitute either of male flowers or of those of both sexes. As the marine Hydrocharitaceae, 1 species of *Euhalus*, *Thalassia*, *Halophila* are known. In all 15 species of sea-grasses belonging to 7 genera are known in Japan. Among eight genera of sea-grasses found in the whole world, only one is wanting in Japan, viz. *Posidonia* which is found only in Western Australia and Mediterranean Sea.

**182. On fresh water plants new to Japan.** (With Japanese résumé). Shigeru MIKI. (Bot. Mag. Tôkyô **48**, 1934, 326-363, 1 pl. and 10 figs.).

Of 9 plants in all the following are new: *Potamogeton biwaensis* hybrida nova, *P. kamogawaensis* hybrida nova, *Vallisneria asiatica* sp. nov., var. *biwaensis* var. nov., var. *higoensis* var. nov., *Nuphar oguraensis* sp. nov., *Myriophyllum oguraense* sp. nov., *Utricularia minor* var. *multispinosa* var. nov.

**183. Über die Bildung der Urease bei *Aspergillus niger*.** Tomoo MIWA und Seiichirô YOSHII. (Sc. Rpts. Tokyo Bunrika Daigaku Sec. B, **1**, 1934, 243-270).

Die Verf. haben die Bildung des Harnstoffes und der Urease bei der Kultur von *Aspergillus niger* und auch *Penicillium glaucum* studiert. Für die Kultur haben die Verf. reines Pepton oder verschiedene Eiweissabbauprodukte (z.B. Seiden-, Fibrin- oder Eialbuminhydrolysat) als alleinige N- und C-Quelle benutzt und dabei haben sie die gleichzeitige Bildung von Harnstoff und Urease beobachtet im Gegensatz zu IWANOFF, welcher unter gleichartige Bedingungen zwar den Harnstoff, nicht aber die Urease in den Pilzmyzelien beobachten konnte. Durch den Zusatz von Glukose oder Fett (Olivenöl) zu der Kulturlösung haben die Verf. das Erhöhen der Urease- und die Erniedrigung der Harnstoffbildung nachgewiesen, was teilweise indirekt auf die durch den Zuckerzusatz verursachte erhöhte Azidität zurückzuführen ist. In der Tat haben die Verf. bei ihren Versuchen, welche besonders für das Stadium des Einflusses der Azidität auf die Ureasebildung gerichtet sind und wobei sowohl organische N-Stoffe als  $\text{NH}_4$ -Salze als N-Quelle benutzt wurden, die erförnde Wirkung der Azidität auf die Ureasebildung konstatieren können. Weiter, haben sie die plötzliche Abnahme der Ureasebildung mit dem Alter des Pilzes beobachtet, was offenbar auf die abnehmende Lebenstätigkeit des letzteren zuzuschreiben ist.

**184. Genetic experiments with *Cosmos* II.** Kiichi MIYAKE, Yoshitaka IMAI, and Kiyo TABUCHI. (Proc. Imp. Acad. **10**, 1934, 33-36, 3 figs.).

In *Cosmos bipinnatus* the capitulum composed exclusively of disk-flowers is recessive to that with both disk- and ligulate flowers (normal), double flower is dominant to simple, long-styled condition is recessive to the normal. In all three cases the segregation takes place according to usual 3:1 ratio.

**185. On the chromosome number in *Brassica juncea* and *B. napus*, their hybrids and one strain derived from them.** (Japanese). Toshitaro MORINAGA. (Japan. Jour. Gen. **9**, 1934, 101-103, 1 fig.-group).

The chromosome number of *Brassica napus* is  $2n = 36$  and  $n = 18$  according to KARPECHENKO, and FRANDSEN and WINGE respectively. The detailed study of the author on this species has led him to the definitive conclusion that this number is 19 instead of 18.

The hybridization between *Brassica juncea* and *B. napus oleifera* has produced in  $F_3$  a certain number of *gigas*-types, of which the chromosome number is considerably larger than in the original. In the  $F_1$ -hybrid *B. juncea*  $\times$  *B. napus* the author has observed the formation of 10 bivalents from 10 chromosomes of both parents. In the first division of PMC in *gigas*-type, besides a small number of univalents the greater majority seem to belong to bivalents.

**186. Cyto-genetic studies on *Oryza sativa* L. I. Studies on the haploid plant of *Oryza sativa* L.** Toshitaro MORINAGA and Eiji FUKUSHIMA. (Japan. Jour. Bot. **7**, 1934, 72-106, 75 text-figs.).

**187. Über das Blühen von *Agave americana* L.** (Japanisch). Mituharu NAGADOMI. (Jour. Japan. Bot. **10**, 1934, 123-127, 5 text-figs.).

Eine grosse Pflanze von *Agave americana* ist im Sommer 1933 in einer gewissen Gegend von Yamagutiken zum Blühen gekommen. Ihr Alter ist unbekannt, doch ist es bewiesen, dass sie vor 60 Jahren aus Formosa dort überpflanzt wurde. Aus dem Untergrundteile dieser Pflanze begannen seit sechs Jahren drei Tochttersprosse sich zu entwickeln, und merkwürdigerweise an jedem dieser Sprosse beobachtete man 1933 die Entwicklung der Blüten sprosse. Ein derselben wurde aus dem Mutterstock ausgetrennt und weiter kultiviert, woraus alle Blütenanlagen sich zu den Laubblättern transformiert sind, während bei zwei anderen, welche mit dem Mutterstock in Verbindung geblieben waren, die Entwicklung aller Blütenanlagen zu den Blüten stattgefunden hatte.

Der Verf. vermutet dabei, dass für das Blühen die Wirkung eines gewissen Wuchsstoffes nötig sei, und dass alle Blütenanlagen bei einem in Rede stehenden Spross zu den Blättern transformiert sind, weil das Ausfliessen des Wuchsstoffes aus dem Mutterstock ausgeblieben ist, wegen seines Austrennens aus demselben. Dieser Stoff könnte durch den zu jungen Stock nicht produziert werden.

**188. Bambusaceae in Japan Proper V-VI.** (Japanese, often with Latin diagnosis). Takenoshin NAKAI. (Jour. Japan. Bot. **10**, 1934, 197-219, 10 figs.; 269-295, 14 figs.).

Continuation of the papers reviewed in this Jour. **7**, (16), No. 62. Among the Bambusaceae enumerated the following are new: *Pleioblastus yakusimensis* sp. nov., *P. argenteostriata* comb. nov., *P. pygmaeus* comb. nov., *P. tsukubensis* sp. nov., *P. purpurascens* sp. nov., *P. gracilis* sp. nov., *P. Chino* var. *Lagdekeri* comb. nov., *P. angustifoliis* comb. nov.

**189. Plantae novae jeholensis I.** (Japanese, English and Latin). Takenoshin NAKAI and Masao KITAGAWA. (Rpts. first scientific expedition to Manchoukuo under the leadership of Shigeyasu TOKUNAGA, June-October 1933. Section N, Pt. I, 1934, 71 pp., 25 pls., 2 text-figs.).

This report consists of two parts. Part I by T. NAKAI contains the description of new woody plants collected in Jehol with illustrations, viz. *Celastrus jeholensis*, *Euonymus mongolicus*, *Zizyphus sativa* var. *lageniformis*, *Ampelopsis humilifolia* var. *trisecta*, *Actinidia megalocarpa*, *Abelia biflora* var. *minor*, *Lonicera wulingensis*, and *Sambucus foetidissima*.

Part II by NAKAI and KITAGAWA contains the description of herbaceous plants of Jehol with illustrations, viz. *Woodsia jeholensis*, *Allium stenodon*, *Tricyrtis puberula*, *Gymnadenia cucullata* var. *maculata*, *Dianthus chinensis* var. *longisquama*, *Aconitum jeholense*, *Sedum austro-manshuricum*, *Chamaerhodiola* nov. gen. with 20 species formerly ranked under *Sedum*, *C. wulingensis*, *Angelica porphyrocaulis*, *Cnidium filisectum*, *C. jeholense*, *Pimpinella Nakaiana*, *Cynanchum sibiricum* var. *gracilentum*, *Trigonotis amblyosepala*, *Dracocephalum robustum*, *Leonurus manshuricum* f. *albiflorus*, *Phlomis jeholensis*, *Scutellaria planipes*, *S. wulingshanensis*, *Veronica angustifolia* var. *dilatata*, *Plantago hostifolia*, *Galium oliganthum*, *Adenophora polyantha* var. *media*, *Chrysanthemum jucundum*, *Cirsium Leo*, *Nabalus Tatarinowii* var. *divisa*, *Saussurea sclerolepis*, *S. s. f. pinnatipartita*, *Serratula cupuliformis*.

**190. Relationship between the peroxylase activity and the germination of cotton seeds.** (Japanese). Sadao NAKATOMI. (Proc. Crop Sc. Soc. Japan **6**, 1934, 118-125).

Some time ago the author has found that the peroxylase activity is much more intense in cotton seeds of Old World species than in those of New World ones (v. this Jour. **6**, (79), No. 284). Further study has shown that seeds of *Gossypium herbaceum* (with intense peroxylase activity) are able to germinate much earlier, have much more intense capacity of absorbing water and are much more resistant against potassium chlorate than those of *G. hirsutum* which have only weak peroxylase activity.

**191. Über die künstliche Keimung des Reispollens.** (Japanisch). Rinzaburô NAKAYAMA. (Agric. & Hortie. **9**, 1934, 1917-1926).

Der beste Keimungsbett für den Reispollen ist 1% Agar mit 12% Rohrzucker. Das Keimungsprozent nimmt bei der von oben gezeigten abweichenden Zuckerkonzentration mehr oder minder ab. Der dabei produzierte Pollenschlauch ist kurz und beträgt höchstens 3-4-mal Durchmesser des Pollens, wenngleich er viel mehr wachsen kann bei der Hinzufügung einer kleinen Menge Diastase dazu. Der Reispollen verliert seine Keimungsfähigkeit bald nach dem Entlassen aus den Antheren, sodass bei den Keimungsexperimenten man den Pollen unmittelbar aus den Antheren in den Keimungsbett fallen zu lassen braucht.

**192. The variation of chromosome number in twin seedlings of common wheat.** (Japanese with English résumé). Sigesuke NAMIKAWA and Jiro KAWAKAMI. (Agric. & Hortie. **9**, 1934, 2241-2244, 2 fig.-groups).—On the occurrence of the haploid, triploid and tetraploid plants in twin seedlings of common wheat. Sigesuke NAMIKAWA and Jiro KAWAKAMI. (Proc. Imp. Acad. **9**, 1934, 668-671, 9 figs.).

In  $F_3$ - and  $F_4$ -families of certain intervarietal crosses of *Triticum vulgare* the authors have found in some few cases the formation of twin seedlings which differ not only in the respective size of their culms, leaves and ears, but also in the degree of fertility. The cytological examination of root-tip cells in such twins has shown the following remarkable facts. Though in 19 cases out of 29 in all both sister seedlings of each twin are found to possess in their root-tip cells the diploid chromosome number ( $= 42$ ), in one case one seedling was seen to contain the haploid ( $= 21$ ) and the other the diploid number, in another case one the tetraploid ( $= 84$ ) and the other the diploid, and in the remaining eight cases the triploid ( $= 63$ ) and the diploid respectively.

**193. Studies on a new *Cephalosporium*, which causes the stripe disease of wheat.** Yosikazu NISIKADO, Hiroyoshi MATSUMOTO, and Kiyû YAMAUTI. (Ber. Ôhara Inst. landw. Forsch. **6**, 1934, 275-306, 7 pls.).

*Cephalosporium gramineum* NISIKADO et IKATA is a new species of parasitic fungi which attacks not only wheat, but also barley, wild oat, etc. The disease is characterized by the appearance of red stripes on the leaf-blades and sheaths, which finally leads to the death of hosts. The fungus propagates itself by means of conidia.



It may be cultured artificially on various nutrient media, optimum temperature for the growth being 20–24°C and optimum pH lying between 4–9. Conidia are very resistant towards the high temperature, e.g. even 60°C. The fungus may overwinter through infected wheat straw, partly through infected soil and seeds.

**194. Metaxenia in the Japanese persimmon. Shape and sweetness.** Yaki-chi NOGUCHI. (Japan. Jour. Bot. **7**, 1934, 61–71, 2 figs.).

**195. On the ring disease of pears and the causal organism, especially on its perfect generation of *Physalospora piricola* n. sp.** (Japanese). Tadayosi NOSE. (Ann. Agric. Exp. Sta. Gov.-Gen. Chosen **7**, 1933, 156–163, 2 pls.).

The ring disease of pear which is extremely prevalent in Corea and causes there the great damage is known especially by producing a number of characteristic blackish gray circular rings in fruits. The infection experiments have proven that this fungus disease may also invade the apples. The artificial culture experiments of the causal organism were performed. The causal fungus corresponds to *Macrophoma Kuwatsukaii* HARA, and since its perfect generation is *Physalospora* and it was never described before, the author proposes a new name *P. piricola*.

**196. On the physiological specialization of *Piricularia oryzae* in Corea.** (Japanese). Tadayosi NOSE. (Ann. Agric. Exp. Sta. Gov.-Gen. Chosen **7**, 1933, 164–173).

A number of *Piricularia oryzae* on diseased leaves from several localities of Corea, Formosa and Tiba Prefecture (in Japan Proper) were isolated and cultured on various nutrient media. The author could distinguish a number of types which behave differently on nutrient media. The infection experiments have shown that the pathogenic activity differs in different types, and thus the fact that the different strains studied by the author are to be regarded to be physiologically differentiated was proven.

**197. *Microspira desulfuricans* and its associated bacteria in the seed-bed of rice in tidal soil.** (Japanese). Tadayosi NOSE. (Ann. Agric. Exp. Sta. Gov.-Gen. Chosen **7**, 1934, 219–244, 3 text-figs.).

In certain parts of Corea, where an extensive area of tidal soil is used for rice culture it was observed recently that the young plants in seed-bed were badly diseased or even wholly destroyed. The examination of the soil there has shown the existence of a strain of *Microspira desulfuricans* (BEYERINCK) VAN DELDER associated with *Pseudomonas* sp. For the existence of *Microspira desulfuricans* which is purely anaerobic the accompaniment of aerobic *Pseudomonas* is indispensable, thus, for instance, the author could observe first the development of the former after the nutrient medium has been covered with a layer of the latter. The reducing activity of *Microspira desulfuricans* in the presence of magnesium, aluminium, ammonium, potassium, sodium takes place most vigorously at 23–32°C, pH 7.3–7.5, and 0.5–0.6% salt content.

**198. Carices formosanae.** Jisaburo OHWI. (Japan. Jour. Bot. **7**, 1934, 187-206).

**199. Symbolae ad floram Asiae Orientalis 10.** (With Japanese résumé). Jisaburo OHWI. (Acta Phytotax. et Geobot. **3**, 1934, 81-87).

The following new species are described among others: *Krascheninikowia Koidzumiana*, *Stellaria pterosperma*, *Lonicera apodantha*.

**200. Natural crossing between Brassica pekinensis and B. Napus.** (Japanese with English résumé). Eizi OKONOJI. (Agric. & Hortic. **9**, 1934, 1095-1100).

*Brassica pekinensis* and *B. Napus* were planted in alternate rows, and seeds from their mutual natural crossing were collected. The hybridization percentage of *Napus* × *pekinensis* is considerably higher than that of *pekinensis* × *Napus*, it being 10 and 2% respectively. Seeds were classified into three classes according to their size, and it was found that in *Napus* × *pekinensis* there was a very conspicuous tendency of its seeds being smaller than pure mother seeds, which much facilitates the elimination of hybrid seeds. This was not however the case in respect to the hybrid *pekinensis* × *Napus*.

**201. Beobachtungen über japanische Moosflora. VI.** (Mit japan. Zfg.) K. SAKURAI. (Bot. Mag. Tōkyō **48**, 1934, 383-399, 418-421).

Die folgenden neuen Arten sind beschrieben unter anderen: *Dicranoweisia pumericicola*, *Pottia ciliatseta*, *Merceya japonica*, *Merceopsis tokioensis*, *Schwetschkea arachnoidea*, *Pseudoleskea cratericola*, *P. scabriseta*, *Leskea Doi*, *Acroporium flagelliferum*, *Rhynchosetegium japonense*, *R. palustre*, *Entodon dependens*, *E. crasirameus*, *Plagiothecium saxicola*, *Stereophyllum nipponense*, *Sematophyllum Toyamae*, *Glossadelphus pernitens*, *Ectropothecium subincubans*.

**202. Systematic status of the genus Ficus.** Tyōsyun SATA. (Jour. Japan. Bot. **10**, 1934, 343-351, 5 text-figs.).

About 26 wild species of *Ficus* occur in Formosa. Their classification was based hitherto upon the leaf or other external character. The author thinks that their classification should be rightly founded on the internal characters of their receptacles, i.e. the relative nature of various kinds of flowers within them. In *Ficus* there are five kinds of flowers, viz. male, gall, female, pseudo-hermaphrodite (male with a pistil along the stamen; style and ovary are present but the latter never contains any seed or pupa), and neuter. The author distinguishes three subgenera as follows: (1) *Urostigma* MIQ., receptacle monoecious and of one kind, always containing male, gall, and female flowers, (2) *Metomorpha* SATA, receptacle dioecious and of two kinds, some containing male gall flowers, and the other female only or female and neuter, (3) *Palaeomorpha* (KING) SATA, receptacle dioecious and of two kinds, some containing pseudo-hermaphrodite, and the other female.

A key for the determination of 26 Formosan species classified according to the above principle is given.

**203. On the systematic importance of the course of vascular bundles in the cone scales of the Japanese Taxodiaceae. (Preliminary report).** (Japanese with English résumé). Yosisuke SATAKE. (Bot. Mag. Tôkyô **48**, 1934, 186-205, 4 fig.-groups).

The course of vascular bundles in the cone scales, seed- as well as bract-scales in four species, viz. *Sciadopitys verticillata*, *Cryptomeria japonica*, *Cunninghamia lanceolata* and *Taiwania cryptomerioides* was studied by the author, not only on sections, but also on the bundles separated out from the surrounding tissue by boiling them in potash, the latter method giving naturally very good results.

The results of the author's investigations are clearly seen from the following table given by him.

	<i>Sciadopitys</i>	<i>Cryptomeria</i>	<i>Cunninghamia</i>	<i>Taiwania</i>
Scale	Seed-scale + bract-scale	Seed-scale + bract-scale	Bract-scale, seed-scale rudimentary	Bract-scale, no seed-scale
Bundle of scales	From the leaf- gap, bundles of seed-scale issuing above, those of bract- scale below it	No leaf-gap, issues as one cylinder	Almost no leaf- gap, issues as one bundle of bract-scale	Almost no leaf- gap, issues as one bundle of bract-scale
Bundle of seed-scale	At first 3, then branches into 7-9	At first 5-6, each of which bifurcates	At first fused with bract-bundle, and then separates into 3 bundles	At first fused with bract- bundle, then divides into 2
Bundle of bract-scale	One, never branches	One, divides into 5, each of which bifurcates	One, divides into 3, afterwards divides into 10-15	One, divides into 3, and then into 9-11
Ovule	anatropous, 7-9	atropous, 2-5	anatropous, 3	anatropous, 2

Basing chiefly on the results of his investigation the author proposed the following classification: (1) *Sciadopitys*—Fam. *Sciadopityaceae*, allied to *Pinaceae-Abietoideae* PILGER; (2) *Cryptomeria*, *Taxodium* and *Sequoia*—Fam. *Taxodiaceae*, (3) *Cunninghamia*, *Arthrotaxis*—Fam. *Cunninghamiaceae*, (5) *Taiwania*, monotypic—Fam. *Taiwaniaceae*.

**204. Systematic importance of the epidermal elements in the leaves of the Japanese Selaginellaceae.** (Japanese with English résumé). Yosisuke SATAKE. (Bot. Mag. Tôkyô **48**, 1934, 259-278, 18 figs.).

For identifying the species of *Selaginella* leaves, sporangial spikes, bracts and spores are generally used as distinguishing characters. The author has made on 24 species of Japanese *Selaginella* a detailed study on the anatomical structure of epidermis of both dorsal and ventral leaves, either on ligulate or aligulate side. Basing on the results of such investigations the author proposes a new classification founded on the epidermal structure of leaves.

(1) *Involvens*-group. Both ligular and aligular epidermis consist of similar elongated cells, while the margin is constituted of sclerotic warty fibres: *Selaginella involvens*, *shakotanensis*, *pseudo-involvens*, *mongolica*.—(2) *Selaginoides*-group. Cells of leaf-margin similar to other epidermal cells; no warty fibres: *S. selaginoides*, *Stantoniana*.—(3) *Uncinata*-group. Ligular and aligular epidermal cells dissimilar in their shape, and the margin consisting of sclerotic (not warty) and very elongated highly thickened fibres: *S. uncinata*, *plana*.—(4) *Nipponica*-group. Ligular and aligular epidermal cells dissimilar just as in the above group, but distinguished from it by the margin composed of sclerotic warty fibres: *S. Savatieri*, *longicauda*.—(5) *Japonica*-group. Ligular and aligular epidermal cells dissimilar, and the marginal cells neither sclerotic nor warty (one exception!): *S. japonica*, *leptophylla*, *Hayatana*, *caulescens*, *Somai*, *kelungensis*, *Rossii*.

**205. Colour inheritance of flower, pubescence and seed-coat in soybean.** (Japanese with English résumé). Tôhei SAWAMURA. (Ann. Agric. Exp. Sta. Gov.-Gen. Chosen 7, 1933, 139-155).

The author has studied the inheritance mode of the colour of flower, pubescence and seed-coat concerning the  $F_2$ - and  $F_3$ -generations of a  $F_1$  which is a natural hybrid found among a pure culture of a Korean strain of soy-bean. The parent strain has white flowers, gray hairs and seed-coats which are buff-mottled on yellow ground, while the hybrid has purple flowers, tawny hairs, and seed-coats which are black-mottled on yellow ground. The study has led the author to the discrimination of five allelomorphic pairs  $C'-c'$ ,  $C-c$ ,  $W-w$ ,  $T-t$ , and  $R-r$ .  $C'$  on one side and  $C$  on the other are responsible for the formation of chromogen in petal and seed-coat, and hairs and seed-coat respectively,  $c'$  and  $c$  having no or very slight effect.  $W$  on one side and  $T$  (also  $t$ ) on the other are responsible for converting the chromogen in petal to purple anthocyanin and that in hairs to brown pigment (tawny hairs) respectively.  $W$  and  $T$  are absolutely linked with  $C'$  and  $C$  respectively, and  $t$  is also absolutely linked with  $c$  to produce gray hairs.  $R$  is responsible for converting the chromogen in seed-coat to black pigment. The anthocyanin pigment is always absent in seed-coat of white-flowered and gray-haired plant. The author has shown in a table the three characters above mentioned (flower, hair, seed-coat colour) concerning 768 strains of soy-beans from Corea, Manchuria, Formosa, and Japan Proper.

**206. On the growth-promoting substance produced by the "bakanae" fungus.** (Japanese with English résumé). Shoichi SHIMADA. (Agric. & Hort. 9, 1934, 2146-2152, 2 text-figs.).

Concerning the well-known growth-promoting substance secreted by the "bakanae" fungus (*Gibberella Fujikuroi*) (v.e.g. Japan. Jour. Bot. 6, (113), No. 407)



the author has studied the relation existing between the hydrogen ion concentration of the culture solution and the fungus secretion. For the experiments the RICHARD's solution containing 1.5% cane-sugar with different pH was used. It was found firstly that the growth-promoting substance is secreted copiously between pH 3.4-4.8, but scarcely between 6.3-8.3. Further, the rate of secretion varies according to the C- and N-source in the culture solution, viz. more plentifully in that containing glucose, fructose or saccharose than in that containing soluble starch, more plentifully in that containing ammonium sulphate, potassium nitrate, asparagin or peptone than in that containing sodium nitrate.

**207. The capability of continuing divisions of the *Tradescantia* pollen mother-cell in saccharose solution.** Kyojiro SHIMAKURA. (Cytologia 5, 1934, 363-372, 1 pl.).

It is generally thought that when the chromosomes of the *Tradescantia* pollen mother-cell are brought within the saccharose solution, they will swell up so considerably that they disappear soon from the view. The author's present study has shown that they are made to remain visible, and even to continue to divide by means of a certain careful treatment.

The balanced solution of NaCl, KCl and CaCl<sub>2</sub> in various respective proportions were used to determine the approximate value of the tonicity of the metaphase I cell of *Tradescantia virginica* by plasmolysis. By the use of approximately isotonic balanced solution with varying cH the influence of the latter upon the distinctness of chromosomes was studied, and it was found that under pH 7 or at most 7.3 which practically coincides with that of pollen slime, the chromosomes are most distinctly visible. They are also very clearly visible or even the division proceeds further when the cells are immersed in the presumably isotonic solution of saccharose (7.93 gr. saccharose in 100 ccm. water), provided that the chromosomes are not taken out from the cell by the rupture of cell-wall (i.e. naked) or the plasma-membrane has not been greatly impaired, preserving the semipermeability of the cell quite intact.

It may be added that the tonicity of the cell will considerably rise with the advancement of the stage of division.

**208. Spiral structure of chromosome in meiosis in *Sagittaria Aginashi*.** Namio SHINKE. (Mem. Coll. Sc., Kyoto Imp. Univ. Ser. B, 9, 1934, 367-392, 3 pls. and 7 text-figs.).

The author has studied concerning the meiosis in the pollen mother-cells of *Sagittaria Aginashi* the spiral structure of chromosomes, i.e. the composition of their chromatic spiral or the chromonema with less chromatic matrix. The general conclusion deduced from his investigation is as follows. In the last premeiotic interphase the nuclear network is seen to be composed of the chromonemata and the anastomoses which connect them, and in the pachytene stage their composition from the fine spiral and the matrix is clearly visible. In the early prophase in the heterotype division the fine nuclear threads are double which is due to the parasynopsis of the two univalents. After passing the telophase the chromosomes in the interkinesis are scarcely changed in their structure and shape; in this stage the direction of the



coiling of sister chromatids are generally the same, though sometimes opposite. The chromosomes in the late heterotypic telophase pass through the interkinesis without undergoing any special change in its structure and shape into the homotypic stage, which is contrary to what we see generally in plants. In the homotypic metaphase the double-coiled nature of the chromonemata was observed, i.e. the ordinary primary spiral of the chromonema forming again in its turn a larger secondary spiral.

The comparison of the behaviour of the chromonemata in *Sagittaria Aginashi* with that of those in *Lilium* and *Lythrum* ends the present paper.

**209. On the germination test of pollen in *Diospyros Kaki* LINN. fl. and allied species.** (Japanese with English résumé). Makoto SISA and Kazuo INUKAI. (Studies from the Inst. Hort., Kyoto Imp. Univ. **1**, 1934, 64-89).

The present studies were performed on some cultivated varieties of *Diospyros Kaki*, *D. Lotus*, and *D. virginiana*. For the artificial germination of their pollen 1% agar-agar and 3/10 m. sucrose solution regulated to pH 5.5 were used. The pollen-grains studied by the authors retained their germination power during 2-3 days after anthesis, and if they are preserved in dry state, for instance, by placing them within a dessicator, this power will not be lost one month or even more. The germination power of pollen grains is largely influenced by the degree of hydrolysis of starch contained therein, so that it attains its maximum at its maturity, when starch disappears there wholly.

**210. Studies on an infection-type of rice diseases analogous to the flower infection. 1. On *Piricularia oryzae* BR. et CAV.** (Japanese with English résumé). Hashio SUZUKI. (Ann. Phytopath. Soc. Japan **3**, 1934, 1-34).

By means of the inoculation experiments the author has proved that *Piricularia oryzae*, the causal fungus of the rice blast disease, is able to infect its seeds before, at or after the flowering time, though the effect of this infection is not perceptible outwards, unless it is not severe. In the seeds infected by this fungus we find the hyphae ramifying in the tissues of the embryo, endosperm, bran layer and glume, or in the space between the latter and the kernels, where conidia were detected. It is clear that the fungus which overwinters in the seeds in any way just indicated becomes active after their germination, indeed the author has observed the death of young seedlings derived from the seeds infected by the fungus. The flower infection by *Piricularia* above cited is similar to that in the case of loose smut in wheat and barley, but the effect differs from that of the latter, inasmuch as in *Piricularia* the effect appears chiefly in the vegetative organ before the flowering, whereas in the other it is limited to seeds in the flowering period. The infection of *Piricularia* is similar neither to "Paleal- und Anthereninfektion" nor to "Blütenkeimlingsinfektion" in loose smut of oats, because the hyphae of *Piricularia* infect the embryo as well as endosperm.

**211. A review of the genus *Cyrtomium* of Japan.** (Japanese). Motozi TAGAWA. (Acta Phytotax. et Geobot. **3**, 1934, 57-67, 4 figs.).

*Cyrtomium* is a genus formerly often included among *Aspidium* or *Polystichum*. It contains 7 species, some new combinations, and some varieties.

**212. *Spicilegium pteridographiae Asiae Orientalis* 7.** (With Japanese remarks). Motozi TAGAWA. (Acta Phytotax. et Geobot. **3**, 1934, 88-96).

The following new species are described: *Dryopteris alpestris*, *D. grandissima*, *D. nokoensis*, *Polystichum Mayebarai*, *P. pseudo-stenophyllum*, *Loxogramme biformis*, *Marginaria pseudo-formosana*, *Plymatodes echinospora*, *P. longisquamata*.

**213. The relation between the absorption of water by plant root and the concentration and nature of the surrounding solution.** Takashi TAGAWA. (Japan. Jour. Bot. **7**, 1934, 33-60, 11 figs. and 20 tab.).

**214. A brief note on the action of the top of a plant upon the absorption of water by the root.** Takashi TAGAWA. (Trans. Sapporo Nat. Hist. Soc. **13**, 1934, 233-236, 1 graph).

In the well known classical experiment on *Nicotiana latissima* SACHS has cut its stem near the base, and compared the quantity water absorbed by its top and that of water exuded from its stump. The author of the present article has performed certain experiments to ascertain the action of the top of a plant (what plant?) upon the water absorption under varied conditions of the surrounding atmosphere. Firstly, the osmotic pressure of the intact plant under various relative humidities was estimated by determining the  $\Delta$ -value of the sucrose solution in which no water absorption takes place (3.98-12.04 atm.). The decapitated plant stopped the water absorption in the sucrose solution of  $\Delta 0.13$  (1.57 atm.). Since the suction force of the top which should be equal to that of intact plant minus that of decapitated root the author has estimated that of the top by basing upon the above data (2.41-10.47 atm.). The general conclusion was that the suction force of the top is pretty large, and equal to 2-8 times as much as that of the root itself.

**215. On the influence of ultra-violet rays upon the protoplasmic viscosity.** N. TAKAMINE. (Cytologia **5**, 1934, 517-519).

Root-tips of *Vicia Faba* were exposed to ultra-violet rays during the time interval varying from 10 minutes to 4 hours. The centrifugal method was used for observing the change of protoplasmic viscosity and of the number of replaced nuclei, and it was compared with that of the control. The result was that the viscosity first decreases slightly, but then increases rapidly.

**216. Über ein neues Mikrokalorimeter zur Messung der Wärmeabgabe von Schimmelpilzkultur.** Hiroshi TAMIYA und Atusi YAMAMOTO. (Acta Phytchim., **7** (1933) 245-263).

Im Jahre 1932 äusserte H. TAMIYA eine Ansicht über die Energetik des Schimmelpilzwachstums, und zeigte dabei, dass der Vorgang vom Körperaufbau auf seinen Bausteinen als Ganzes eine exotherme Reaktion darstellt, und dass während des Pilzwachstums nicht nur die Gesamtmenge der Atmungsenergie, sondern auch diejenige Menge der Energie, welche der Energiedifferenz zwischen Baustein und Pilzkörper entspricht, als Wärme abgegeben werden soll. Um dieses auffallende Sachverhältnis durch direkte Wärmemessung näher festzustellen, haben Verf. ein

neues Mikrokalorimeter konstruiert, indem sie darauf Rücksicht nahmen, dass zur einwandfreien Aufstellung der Energiebilanz es höchst von nöten ist, neben der Wärmeabgabe und der Gewichtszunahme noch die echte Grösse der O<sub>2</sub>-Atmung genau auszumessen, was nach RQ-Theorie von TAMIYA wenigstens bei Zugabe der C-Quellen mit "Hyperquotient" (z.B. Glucose) nicht, wie es bei anderen Forschern geschieht, durch die CO<sub>2</sub>-Abgabe allein, sondern erst durch genaue Ermittlung des O<sub>2</sub>-Verbrauchs erzielt werden kann. In der vorliegenden Mitteilung ist eine ausführliche Darstellung über das Prinzip und die Einrichtung dieses Apparates sowie auch über die Resultate der Eichungsversuche vorgebracht. Die Ergebnisse der Versuche, welche wirklich mit der Pilzkultur ausgeführt wurden, sollen bald in einer anderen Arbeit mitgeteilt werden. (YAMAGUTCHI)

**217. Über die Chromosomenzahlen bei den Anthocerotaceen, mit besonderer Rücksicht auf ihre Heterochromosomen.** (Japan. m. deutsch. Zfg.). Seizi TATUNO. (Bot. Mag. Tôkyô **48**, 1934, 54-60, 26 Textfig.).

Drei von dem Verf. untersuchte monözische Anthocerotaceen, nämlich *Anthoceros laevis*, *A. Miyabeanus* und *Megaceros tosanus* enthalten je 6 gametische Chromosomen. Bei jeder Art ist ein durch die Heteropyknose ausgezeichnetes Chromosom (Heterochromosom) vorhanden.

**218. Über die Gestalt von *Brassicoraphanus*.** (Japanisch). Yasufusa TERA-SAWA. (Proc. Crop Sc. Soc. Japan **6**, 1934, 159-163, 1 Taf.).

Früher hat der Verf. durch die Kreuzung *Brassica chinensis* ♀ × *Raphanus sativus* ♂ einen Bastard, *Brassicoraphanus amphidiploida* bekommen (vgl. Japan. Jour. Bot. **6**, (55), Nr. 189 u. (89), 320). Die Kultur während den folgenden vier Generationen zeigt, dass er sich ganz konstant verhält. In dem vorliegenden mit 1 Tafel ausgestatteten Aufsatz beschreibt der Verf. tabellarisch die Gestaltverhältnisse zwischen beiden Eltern und deren Bastard. Danach liegt die Gestalt der Bastard im allgemeinen zwischen beiden Eltern, doch nähern sich die Samen eher denselben von *Brassica* als denselben von *Raphanus*; während die Blüten viel ähnlicher denselben der letzteren Pflanze als denselben der ersteren sind.

In *Brassicoraphanus* sind die Blüten sowie Früchte bedeutend grösser als dieselben von F<sub>1</sub>; die Fruchtlänge, der Pollendurchmesser, die Länge des Blütenschaftes sind grösser als dieselben jedes Elters.

**219. The after-effect of the fungus filtrate of *Gibberella Fujikuroi* on rice plants.** Yoshihiko TOCHINAI und Kiichi ISHIZUKA (Trans. Sapporo Nat. Hist. Soc. **13**, 1934, 143-152, 1 fig.).

*Gibberella Fujikuroi*, the well known causal fungus of the "Bakanae"-disease is characterized by causing the abnormal elongation of the rice seedlings. In order to study, whether the toxin produced by the fungus will still have its effect after the seedlings had been transplanted to the toxin-free place, a series of experiments were performed on two strains among 47 ones got by the author. The KNOP solution containing 0.5% grape-sugar was inoculated with the fungus, naturally with all precautions necessary for such experiments. After a certain number of days, the

filtrate was got from this solution. Rice seedlings were cultivated in sand, to which the filtrate diluted with the KNOP solution was previously poured in, and their behaviour was compared with that in the control culture. Their characteristic abnormal elongation was observed. Thereafter the seedlings were transplanted in their early stage of growth to the toxin-free sand, whereupon they were observed to be free from the "Bakanae" symptoms, and have given the harvest which is not inferior to that of the control culture. No after-effect was thus observable.

**220. On the injurious fungi which overwinter in the rice straw.** (Japanese). Yoshihiko TOCHINAI and Mutsuo TERUI. (Agric. et Hort. **9**, 1934, 24 pp.).

Since the prevention of the primary infection is naturally very effective for the control of plant diseases, the sterilization of grains and straws of rice will be of course of utmost importance for the success of rice culture.

To contribute to the knowledge concerning the sterilization of rice straws the authors have collected at various localities in Hokkaidô pieces of rice straws which have overwintered. From them which were sterilized outwards to remove various organisms having nothing to do with the disease the various pathogens living in the internal tissues were isolated, viz. *Acremonium atra*, *Alternaria oryzae*, *Epicoccum purpurascens*, *Fusarium lateritium*, *F. merismoides*, *F. subulatum*, *Gibberella Fujikuroi*, *G. Saubinetii*, *Piricularia oryzae*. The infection experiments of each fungus were performed on young rice seedlings. Among the fungi above indicated, the three first ones are not much injurious, and can survive in Hokkaidô only under favourable conditions. The severe pathogenity of *Fusarium*, *Gibberella* and *Piricularia* are well known, and besides they are able to survive in Hokkaidô even when extreme climatic conditions are prevailing, except the last one.

**221. Note on some new species of fungi collected in Mt. Taisetsu.** Yoshihiko TOCHINAI and Suewo YAMAGATA. (Trans. Sapporo Nat. Hist. Soc. **13**, 1934, 144-148, 4 figs.).

The following new species of Ascomycetes from Mt. Taisetsu, the highest mountain in Hokkaidô, are described: *Meliola Vaccinii*, *Didymosphaeria atropunctata*, *Gnomonia polyarca*, *Bagnisiopsis Coptidis*.

**222. Matsudake of Japan and America.** (Japanese). Kogo TOGASHI. (Agric. & Hort. **9**, 1934, 507-519, 7 figs.).

The study of an American mushroom which the Japanese living in the Pacific border, Oregon and Washington use to identify with the famous Japanese Matsudake (*Armillaria Matsutake*) revealed the fact that it is really *Armillaria ponderosa* (PECK.) SACC., Syn. *A. arenicola* MURRILL, *A. magnavellaris* MURRILL). Both are very similar to each other, but in the American species the cap is much paler in colour and the development of scales less significant than in the Japanese one.

**223. Spore-size variability in subsequent spore prints of some hymenomycetous fungi.** Kogo TOGASHI and Kojiro ODA. (Trans. Sapporo Nat. Hist. Soc. **13**, 1934, 121-125).



In *Armillaria Matsutake* it was ascertained by certain authors that the size of spores derived from one and the same pileus is variable, when judged from the spore print made in usual way. The authors of the present article have performed similar experiments on other Hymenomycetes, viz. *Armillaria mellea*, *Hypophoma sublateritium*, *Pholista adiposa* and *Collybia velutipes*. The spore prints of these fungi were made for successive days, each day once at a fixed hour. The biometric comparison of such prints of each fungus in respect to the length and width of spores has shown the existence of a certain variability. One instance of the length may be cited as follows: *Collybia velutipes*, first day  $6.19 \pm 0.05$ , second day  $6.03 \pm 0.05$ , third day  $6.11 \pm 0.04$ , fourth day  $6.32 \pm 0.05$  (in mm.).

#### 224. A list of parasitic fungi collected on Mt. Hayachine, Iwate Prefecture.

Kogo TOGASHI and Fusaji ONUMA. (Bull. Imp. Coll. Agric. & Forest. No. 17, 1934, 74 pp., 11 text-figs.).

Among 184 species in all the following are new: *Peronoplasmodium elatostomae*, *Haplotheceium coptidis*, *Puccinia Yamadana*, *Phleospora cacialiae*, *Colletotrichum actinidiae*, *C. luzulae* on *C. luzula campestris*, *Diplocladium hydrangeae*, *D. codonopitidis*, *Ovularia hayachinense*, *Septocydrum aesculi*, *Cordana parasitica*. All above species are described with illustrations. The paper ends with the index of fungi and hosts.

225. Biometrical and biological studies of *Albugo candida* (PERS.) O. KUNTZE in connection with its specialization. Kogo TOGASHI and Yoshinosuke SHIBASAKI. (Bull. Imp. Coll. Agric. & Hort. No. 18, 1934, 88 pp., 7 text-figs., 48 tables).

The size of conidia in *Albugo candida* got from a large number of sources was measured by a great number of persons and under different conditions. Thanks to this measurement it was ascertained that the conidia got on *Brassica* and *Raphanus* measure  $29 \times 18 \mu$  on the average, and those got on *Cardamine*, *Capsella*, *Draba* and *Arabis*  $15.5 \times 14.5 \mu$ , the difference between the two strains being thus 4-5  $\mu$ . The product of the conidium length by its width is on the average 364.0081 in the former group, and 218.3900 in the latter, so that the ratio between the two groups is 1.67. The authors propose to call the former group "var. *macrospora*" and the latter "var. *microspora*." The inoculation experiments were performed, and five distinct forms were distinguished, viz. (1) on *Capsella bursa-pastoris* var. *auriculata*, (2) on *Draba nemorosa* var. *hedearpa*, (3) on *Arabis hirsuta*, (4) on *Raphanus sativus* var. *macropodus*, and (5) on *Brassica cernua*, *B. chinensis*, *B. pekinensis* and *B. Rapa*.

*Albugo* on *Eutrema Wasabi* may be a form different from five forms above cited.

226. Genetisch-zytologische Studien an Weizenspeltoiden I. Speltoide der C-Serie. (Japanisch m. deutsch. Zfg. u. Figurenerklärung). Isamu UCHIKAWA. (Plants and Animals 2, 1934, 851-864, 12 Abb.).

Bei den Weizenspeltoiden, und zwar denselben der C-Serie (aus HUSKINS stammend) sind 21 II Chromosomen, beide im homo- und heterozygoten Zustand, vorhanden. Bei den Heterozygoten besteht ein Paar unter 21 im ganzen aus einem kleinen und



einem grösseren Chromosom (heteromorphes Paar), während bei den Homozygoten diese Paarenpartner gleichgross sind. In Uebereinstimmung mit den NISHIYAMAS Angaben über Fatuoidhafer (vgl. Japan. Jour. Bot. **6**, (109), Nr. 391 u. 392) nimmt der Verf. an, dass dieses heteromorphe Paar als  $cs_1$  bezeichnet werden kann, wobei, ein durch Fragmentierung des C-Chromosoms entstandene Stück ist, sodass die Heterozygoten als  $20_{II} + cs_1$ , und die Homozygoten als  $20_{II} + s_1s_1$  bezeichnet werden muss.

**227. Über die Entstehung der Vakuolen im Kern.** Bungo WADA. (Cytologia **5**, 1934, 248-252, 1 Taf.).

Bei den mikrurgisch angestochenen Staubfadenhaaren von *Tradescantia discolor* geschieht es oft, dass beim Verschmelzen der Spalthälfte der Chromosomen zu einem Kern einige zytoplasmatische Teilchen zufällig in die verschmelzenden Tochterchromosomengruppen eingeschlossen werden. Solche Teilchen verflüssigen sich, die grösseren früher als die kleineren, und bilden die Vakuolen im Kern, welche dank der osmotischen Wirkung der in dem letzteren enthaltenen Flüssigkeit, sich je zu einer dünnwandigen Blase dehnen. Folgt dann die Entleerung des Vakuoleninhaltes an dem Kern und unmittelbar nach demselben Vorgange sieht man die hohle Räume an der Kernoberfläche übrig, wenn nach einiger Zeit die Kerne wieder zu ihrer normalen Gestalt zurückkommen werden.

**228. On the difference of X-bodies in green and yellow mosaic of wheat.** (Japanese with English résumé). Eitarô WADA and Hiroshi HUKANO. (Agric. & Hort. **9**, 1934, 1778-1790, 6 fig.-groups).

A number of wheat (*Triticum vulgare*) varieties were planted in the experimental field, and treated in exactly the same way. Some of them were at first attacked by yellow mosaic, and some time later others by green-mosaic, and still later some by the mixture of both kinds of mosaic diseases. The microscopical examination of a strip from the leaf epidermis of diseased plants has revealed the two kinds of X-bodies: the one is vacuolate, oval or elongated, either larger or smaller than the nucleus of the host-cell, and single in each of the latter (A-type), while the other is homogeneous, oval or irregular in form, smaller than the first, and generally 2-3, even 5 in one cell (B-type). The plant-cell attacked by the mixture of both kinds of mosaic contains both kinds of X-bodies (C-type). The results of the author's investigation are therefore on the whole in accordance with those of MAKINNEY who distinguished two kinds of viruses, green and yellow mosaic respectively.

**229. Embryological studies on the different seed-development in reciprocal interspecific crosses of wheat.** Shunjiro WAKAKUWA. (Japan. Jour. Bot. **7**, 1934, 151-185, 2 pls. and 7 text-figs.).

**230. Entstehung des Floralpolsters von *Mitrastemon Yamamotoi*.** Kiyohiko WATANABE. (Proc. Imp. Acad. **10**, 1934, 177-179, 2 Textabb.).

In seiner früheren Arbeit (vgl. diese Zeit. **7** (27), Nr. 99) berichtete der Verf. nach HAYATA, dass in der Wirtsrinde die Vegetationsorgane von *Mitrastemon Yamamotoi* (deren Stränge wagerechte Fäden von ihm genannt werden) netzförmig ver-

laufen. Diese Angabe Verfs. ist jetzt nicht ganz richtig zu sein gefunden, da diese netzförmige Stränge wirklich Stränge von Tracheiden sind und die Zwischenräume dieses Netzes durch das Parenchym von *Mitrastemon* erfüllt sind. Das Vegetationsorgan von *Mitrastemon* in der Blütenregion bildet somit einen Hohlzylinder, welcher Floralpolster genannt werden kann. In dem vorliegenden Aufsatz wird ausführlich die Entstehungsweise solches Floralpolsters beschrieben.

**231. The marine Chlorophyceae from Ryukyu, especially from the vicinity of Nawa.** Yukio YAMADA. (Jour. Fac. Sc., Hokkaido Imp. Univ. Ser. V (Bot.) **3**, 1934, 33-88, 53 text-figs.).

After the publication of HARVEY on the marine algae of Ryūkyū almost nothing has appeared concerning them except some short or fragmentary notes of certain Japanese authors.

The present paper of the author contains in all 59 species of Chlorophyceae arranged under 26 genera and 11 families. Besides some new forms one new genus and two new species are presented, viz. *Acetabularia* (*Polyphysa*) *clavata*, *Bryopsis ryukyuensis*, *Pseudodichotomasiphon* gen. nov. with *P. constricta* (YAMADA) comb. nov.

**232. Enumeration of marine algae in Urup Island, especially in the neighbourhood of Iema.** (Japanese). Yukio YAMADA. (Rpt. Algal Res. Sta., Fac. Sc., Hokkaido Imp. Univ. No. **3**, 1934, 1-50, 20 text-figs.).

In this paper are enumerated the green, brown and red algae collected in the Urup Isl. (belonging to the Kurile Isl.), especially in the vicinity of Iema. For each species the literature and description are given, often with illustrations.

I. Chlorophyceae (Ulvaceae 4 sp., Cladophoraceae 3 sp.)

II. Phaeophyceae (Ectocarpaceae 1 sp., Entocoeliaceae 4 sp., Chordariaceae 3 sp., Dictyosiphonaceae 1 sp., Desmarestiaceae 2 sp., Laminariaceae 11 sp., Fucaceae 2 sp.).

III. Rhodophyceae (Bangiaceae 3 sp., Dumontiaceae 1 sp., Calymeniaceae 2 sp., Nemastomonaceae 1 sp., Gigartinaceae 1 sp., Rhodymeniaceae 2 sp., Ceramiaceae 3 sp., Delesseriaceae 1 sp., Rhodomelaceae 4 sp.).

**233. Über die Beeinflussung der Sauerstoffstoffatmung von verschiedenen Bakterien durch Blausäure und Kohlenoxyd. Beiträge zur Atmungsphysiologie der Bakterien I.** Seizaburo YAMAGUCHI. (Acta Phytochim. **8**, 1934, 154-172, 5 Textfig.).

Der Einfluss der Blausäure (M/2500 bzw. M/1000) und des Kohlenoxyds (95%) auf die Sauerstoffatmung von 25 cytochromführenden aeroben sowie fakultativ anaeroben Bakterienarten wurde bei 30° mittels WARBURG-Manometers untersucht, und eine kurze Diskussion über den Atmungsmechanismus der betreffenden Bakterienzellen wurde angestellt. Nach dem Verhalten gegen die obenerwähnten Atmungsgifte lassen sich die Bakterien in 4 Gruppen klassifizieren. I. Gruppe: HCN- und CO-refraktäre Atmung (*Mic. ochraceus*, *Mic. citreus* und *Sarc. lutea*), II. Gruppe: HCN-hemmbar und CO-nichthemmbare Atmung (3 Kugelbakterien, 2

*Pyocyanus*-Arten und 2 *Fluorescens*-Arten), III. Gruppe: HCN- und CO-hemmbar Atmung, CO-Hemmung fast nie lichtempfindlich (4 *Escherichia*-Arten, *B. proteus vulgaris*, *Az. chroococcum*, *B. mycoides* und *Bact. tumefaciens*), IV. Gruppe: HCN- und CO-hemmbar Atmung, CO-Hemmung durch Licht deutlich aufgehoben (3 Staphylokokken, *B. mirabilis*, *Bact. xylinum*, *B. subtilis* und *B. mes. vulgatus*). Bei den Bakterien der I. bzw. II. Gruppe kann die Atmung wahrscheinlich durch Einschaltung irgend eines CO-unempfindlichen bzw. CO- und HCN-unempfindlichen Zwischensystems verlaufen, und das vorhandene Cytochromsystem spielt vielleicht fast nie die eigene Rolle in dem Atmungsprozess. Im Gegensatz dazu wird die O<sub>2</sub>-Übertragung bei den Bakterien der III. bzw. IV. Gruppe durch das Cytochromsystem ermöglicht, und zwar kann man sehen, dass die ersteren, die die lichtunempfindliche CO-Hemmung zeigen, der a Komponente des Cytochroms entbehren, während die letzteren, bei denen CO-Hemmung photochemisch aufhebbar ist, stets Cytochrom a besitzen. (Verfasser)

**234. Weiteres über den isoelektrischen Punkt der Bakterien.** G. YAMAHARA und S. ABE. (Sc. Rpt. Tokyo Bunrika Daigaku Sec. B, 1, 1934, 221-229, 13 Tab.).

Mitteltst der Verwendung der Flockungs- und Kataphorese-Methode (vgl. diese Zeit. 6, (91), Nr. 325) wurde der IEP der folgenden Bakterien bestimmt, nämlich *Staphylococcus aureus*, *Sarcina lutea*, *Bacillus pyocyaneus*, *B. pseudodiphtheriae* (?), *B. pertussis*, *B. subtilis*, *B. anthracis*, *B. proteus*, *Diplococcus gonorrhoeae*. Die Versuchsergebnisse sind wie folgt. Jeder von den untersuchten Bakterienarten kommt wenigstens ein EIP zu, welcher der Regel nach zwischen pH 2-4 liegt. Meistens stellt sich das Flockungsmaximum um 0,1-0,8 pH-Einheit alkalischer heraus als der Umladungspunkt, ausgenommen *B. subtilis*, wo diese Abweichung merklicher ist. Bei *B. pseudodiphtheriae* wurde nach 24 Stunden das zweite Flockungsmaximum gefunden um pH 4,3. Keine Beziehung wurde zwischen dem festgestellten pH<sub>I</sub>-Wert und der GRAMS Färbung gefunden. Auch die Tatsache wurde nachgewiesen, dass die Pufferlösung nicht den pH<sub>I</sub>-Wert beeinflusst.

**235. Karyogenetische Untersuchungen bei der Gattung *Rumex* L. Hetero- und Euploidie bei *Rumex acetosa*.** Yukio YAMAMOTO. (Cytologia 5, 1934, 317-336, 53 Textabb.).

Die karyogenetischen Studien verschiedener Formen von *Rumex acetosa* führten zur Kenntnis des Verhältnisses zwischen dem Geschlecht und der Chromosomenformel.

	Chromosomenzahl (2n)	Chromosomenformel	Geschlecht
1.	18	2X+1Y <sub>1</sub> +1Y <sub>2</sub> +14a	♀
2.	16	X+2Y <sub>1</sub> +1Y <sub>2</sub> +12a	♂
3.	15	2X+1Y <sub>1</sub> +2Y <sub>2</sub> +12a	♀
4.	16	X+1Y <sub>1</sub> +2Y <sub>2</sub> +12a	♂
5.	15	2X+1Y <sub>2</sub> +12a	♀
6.	25	3X+18a	♀
7.	22	X+Y <sub>1</sub> +Y <sub>2</sub> +19a	♂
8.	16	X+Y <sub>1</sub> +Y <sub>2</sub> +13a	♂
9.	15	2X+13a	♀

woraus man sehen kann, dass in den obigen Formen das Zahlenverhältnis der Autosomen zu den X-Chromosomen bei dem Zustandekommen des Geschlechtsausdruckes ausschlaggebend ist, aber die Y-Chromosomen dabei keine Rolle spielt. Betreffend weitere einzelne Tatsachen sei auf das Original verwiesen.

**236. The haploid plant of common wheat, *Triticum vulgare* HOST.** Yoshito YAMASAKI. *Cytologia* **5**, 1934, 305-307, 3 figs.).

The discovery of three haploid mutants of *Triticum vulgare*, each among different strains, is announced.

**237. The second report of the behaviour of the pollen tubes in the production of seedless fruits caused by interspecific pollination.** (Japanese with English résumé). Sadao YASUDA. (*Japan. Jour. Gen.* **9**, 1934, 124).

It was formerly reported by the author that the pollen of *Petunia violacea* stimulates the parthenocarpic development of the egg plant (cf. *Japan. Jour. Bot.* **5**, (52), No. 172). The author has further observed that the injection of water extract of *Petunia* pollen often leads to the growth of the ovarian tissue of the egg plant and often to the formation of parthenocarpic fruits. The growth of the ovarian tissue is due to the cell-division stimulated out by the injection process. Since this growth might be due to the action of wound hormone, but not to that of the pollen extract, the ovary was injected with pure water or water extract of tomato pollen, or was simply pricked by a needle, whereby no growth was observed.

**238. Physiological research of self-incompatibility in *Petunia violacea*.** Sadao YASUDA. (*Bull. Imp. Coll. Agric. & Forest. Morioka No.* **20**, 1934, 95 pp. and 11 figs.).

This is a complete collection of the author's results of the well-known experiments on the phenomenon of self-incompatibility of *Petunia violacea* which were published in various places since many years ago, and also reviewed several times in this Journal. The general results of the author's very detailed experiments are that the self-incompatibility in this plant is due to the secretion of a certain special water-soluble substance from the ovary, especially from the placenta which inhibits the germination of pollen as well as the growth of the pollen tube, and also accelerates the cross-fertilization. The exceptional self-fertility of some self-incompatible plants fertilized during the bud stage is due to the fact that the inhibiting substance is not yet produced. The self-fertility of usually self-incompatible plants in old age, under low temperature, and also the so-called the end season fertility, all these are due to the paucity or want of this substance.

**239. On some lethal factors in *Pharbitis Nil*.** Kono YASUI. (*Japan. Jour. Gen.* **9**, 1934, 184-186).

The cross between certain green and yellow strains of *Pharbitis Nil* has given in  $F_2$  the individual *GgAlal*, *g* and *al* referring to yellow and albino, and *G* and *Al* representing the corresponding allelomorphs green and non-albino. The segregation of this individual has shown that *al* in homozygous condition acts as a lethal factor, producing albinos, when associated with either *G* or *g*.



The writer has got a strain, of which pollen is quite sterile, though the ovules are normal. Breeding experiments have indicated that the pollen sterility is caused by a lethal factor.

*si* (*fe*) is a factor for causing the *sisi* formation of flowers. The individuals *sisi* are sterile, though not wholly. Pollen-grains are variable in their size, of which small ones have no fertilizing power. The ovules are almost wholly sterile.

**240. Genetical studies in *Zea Mays* L. 9. Yellow and colourless endosperm.** (Japanese). Kono YASUI. (Bot. Mag. Tôkyô **48**, 1934, 179-185).

The colour of the caryopses of *Zea Mays* is due either to their external coat or endosperm, and in the latter case either to the aleurone layer or the endosperm proper itself. The writer's subject of experimentation refers to the latter case, where the colour is caused by carotin or xanthophyll in the plastids, especially present near the nuclei. Various genes were identified. Since it is impossible to describe in this short abstract all details of the writer's experiments executed for this purpose, only the results are shortly noticed here. Two kinds of white were found, i.e. dominant or recessive against yellow. Three kinds of genes responsible for yellow were identified,  $Y_2$  for deep yellow (perhaps responsible for xanthophyll formation),  $Y_3$  for pale yellow, and  $Y_4$  for sulphur yellow (perhaps responsible for carotin formation).  $Y_2$  and  $Y_3$  are dominant to  $y_2$  and  $y_3$  (recessive) respectively.  $Y_4$  which is inactive by itself, can produce pale yellow only in cooperation with  $Y_2$ ,  $Y_3$ , etc.



## VI. INTERNATIONAL BOTANICAL CONGRESS

Amsterdam, September, 2-7, 1935.

The Organizing Committee of the VI. International Botanical Congress announces that the following topics preliminarily have been chosen for discussion in the sections:

AGR. Agronomy. 1). Interactions between roots and soil; interactions between plants. 2). Virus diseases. 3a). Weed flora as an indicator of soil conditions in agriculture. 3b). Grassland associations. 4a). Genetics and breeding of immune varieties. 4b). Inbreeding. 5). Importance of microbiological investigations in the study of agricultural problems. 6). Influencing the cycle of development in plants.

CYT. Cytology. 1). Structure of chromosomes. 2a). Crossing-over versus conversion. 2b). Terminology of cytology and genetics. 3). Pairing of chromosomes in polyploids. 3b). Reduction division in fungi. 4). Chain- and ring-formation of chromosomes. 5a). Submicroscopical structure of the cell-wall. 5b). Vacuome, chondriome, plastids. 6). Colloid chemistry of protoplasm; vital staining.

GEN. Genetics. 1a). Experimental mutations. 1b). Genetical basis of size and form. 2b). Crossing-over versus conversion. 2b). Terminology of cytology and genetics. 3a). Sexuality in fungi. 3b). Reduction division in fungi. 4a). Genetics and breeding of immune varieties. 4b). Inbreeding. 5). Taxonomy and genetics. 6a). Plasm and genotype in their mutual relations. 6b). Letal factors.

GEO. Geobotany, ecology and phytogeography. 1). Climax associations in N. W. Europe and N. America. 2). Cartography: a). Vegetation maps; b). Area maps. 3). Flora and vegetation area. 4). Plant-geography in younger formations. 5). The halophyte problem. 6a). Classification and nomenclature of vegetation units. 6b). Miscellaneous papers.

MOR. Morphology and anatomy. 1a). Size and form. 1b). Genetical basis of size and form. 2a). Phytohormones; general paper. 2b). Leaf arrangements. 3). Flower-morphology. 4). Female fructification and phylogeny of Conifers. 5a). Wood-anatomy. 5b). Relations between anatomy and external morphology. 6). Morphology of Bryophytes.

MYC. Mycology and bacteriology. 1). Differential characters in Hymenomycetes. 2). Nomenclature of fungi. 3a). Sexuality in fungi. 3b). Reduction division in fungi. 4). Biologic forms of fungi. 5). Importance of microbiological investigations in the study of agricultural problems. 6). Phylogeny and taxonomy of Phycomycetes.

PATH. Phytopathology. 1). Biological basis of plant-quarantine. 2). Virus diseases. 3). Various papers. 4). Biologic forms of fungi. 5). Immunisation. 6). Physiologic diseases.

PB. Palaeobotany. 1). Geobotanical provinces in the older formations. 2). Caytoniales and Pteridospermae and the evolution of Angiosperms. 3). Flower-morphology. 4). Plant-geography in younger formations. 5). Synchronium and uniformity in palaeozoic and mesozoic floras. 6). Various papers.

PH. Plant-physiology. 1). Photosynthesis. 2a). Phytohormones; general paper. 2b). Phytohormones; various papers. 3). Oxidation, reduction and metabolism. 4). Permeability and the accumulation of mineral elements. 5a). Submicroscopical structure of the cell wall. 5b). Translocation of plastic materials. 6). Influencing the cycle of development in plants.

SYS. Taxonomy and nomenclature. 1). Various papers. 2). Caytoniales and Pteridospermae and the evolution of Angiosperms. 3). Flower-morphology. 4). Female fructification and phylogeny of Conifers. 5). Taxonomy and genetics. 6). Phylogeny and taxonomy of Phycomycetes.